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TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK..... 137
A 6-Cu.-Yd. Dipper Dredge for Use on the Great Lakes (illustrated)..... 138
Methods of Determination of Latitude, Longitude and Solar Time in Reconnoissance Surveys..... 138
A Machine for Drawing Seamless Steel Tubes with Longitudinal Ribs (illustrated)..... 142
Notes from the Engineering Schools..... 147
Drill-Grinding Machine with Single Adjustment (illustrated)..... 148
Plate-Girder Bridges on Track Elevation Work... 149
An American Architectural Engineering Exhibit at the Paris Exposition..... 149
A Variable Speed Power-Transmission Apparatus (illustrated)..... 150
Recent Examples of Low Freight Rates in Rail Transportation..... 150
American Locomotives for the South African Republic (illustrated)..... 150
New Union Passenger Station at Springfield, Ill.; Illinois Central R. R. (with two-page plate)..... 151
Rotary Pump with Sliding Blades (illustrated).... 152
Book Reviews..... 152
EDITORIAL NOTES..... 144
The Prospects of an Erie Canal Enlargement—New Estimates for an Erie Barge Canal—Engineers' and Attorneys' Compensation Contrasted—Leaky Plumbing at Hartford—The Results of Water Waste at Saratoga—Instructions for Determining Longitude and Latitude.
EDITORIAL:
Relative Railway Freight Rates on Large and on Small Shipments..... 145
LETTERS TO THE EDITOR..... 146
A New Kind of Wireless Telegraphy—Skew Connection Details for Roof and Bridge Work (Correction)—Repairing Steel Tapes—The Barren Island Reduction Works—Regarding Transit Surveys.

NEW YORK UNDERGROUND RAPID TRANSIT railway affairs reached a satisfactory conclusion during the past week. On Feb. 19 articles of incorporation of the Rapid Transit Subway Co. were filed at Albany, N. Y. The company was incorporated with a capital stock of $6,000,000, and was organized with the following officers: President, August Belmont; Vice-President, Walter G. Oakman; Treasurer, Wm. C. Emmett, and Secretary, Frederick Evans. On Feb. 24 Mr. John B. McDonald, the successful bidder, signed the contract for constructing the road and deposited the required $6,000,000 bond. Mr. Charles Sooysmith, M. Am. Soc. C. E., will be the engineer to the contractor. Mr. Geo. S. Rice, M. Am. Soc. C. E., has been appointed deputy chief engineer of the Rapid Transit Commission, of which Mr. Wm. B. Parsons, M. Am. Soc. C. E., is Chief Engineer. A special committee of the commission is now at work formulating an organization for the remainder of its engineering staff. At the meeting of the commission on Feb. 26 a resolution was passed requiring,

That the chief engineer investigate and report to this board his opinion as to the practicability and cost of an extension of the rapid transit railroad from the City Hall to the South Ferry, and thence under the East River to the Borough of Brooklyn; and for the purpose of such investigation the chief engineer may employ assistants and incur expense, subject to the approval of the president of the board, to an amount not exceeding $10,000.

At the same meeting the commission also passed a resolution making requisition on the Board of Estimate and Apportionment of New York city "for the authorization of the full amount of corporate stock of the city of New York sufficient to pay the entire estimated expense" of the road, which is $36,500,000, made up of Mr. McDonald's bid of $35,000,000 for construction, a further sum of $1,000,000 for terminals and of $500,000 for real estate. Another resolution was passed informing the contractor that the work of construction must be commenced within 30 days from the signing of the contract, or before March 26. A joint committee of the New York Municipal Assembly has been appointed to make plans for a formal ceremony to celebrate the commencement of work, and the indications are that this ceremony will be set for March 17.

GRADE CROSSINGS of steam and electric railways have many special elements of danger, as shown by an editorial discussion of the subject in our issue of May 18, 1899. The city of Cleveland, O., is probably the first to initiate a movement for the elimination of such crossings. The cost is estimated at $1,140,000, of which the city's share would be about $400,000, the Ohio law apportioning the cost at 65% for the railway company and 35% for the city. The city is asking the street railway companies to pay this 35%, and as these companies have short terms of franchise as compared with the steam railways, the city will agree to reimburse them in the event of their failing to secure a renewal of their franchises.——The West Jersey Traction Co., of New Jersey, will be required to carry its line under the Pennsylvania R. R. at Haddonfield, N. J., according to a decision of the State Chancellor, owing to the dangerous character of any grade crossing at that point. There are about 70 regular trains and often 30 extra or special trains per day. The subway and approaches will cost about $13,000.

THE GRADE CROSSING BILL FOR WASHINGTON, D. C., chiefly relating to the raising and lowering of the tracks of the Baltimore & Potomac R. R., in that city, is opposed by the War Department, so far as it relates to parks under the jurisdiction of the Department and the proposed two bridges across the Potomac River. As to the first item the report of Col. Bingham to Chief of Engineers Gen. Wilson shows that about 34½ acres of such parks would be invaded in the proposed changes, and in some cases, what is left of this government property would be practically ruined. For example, it is proposed to take 12 acres from Garfield Park and to ruin the remainder by the proximity of yards, tunnel entrances, etc. From the Mall 14 acres would be taken, ruining a reservation made by President Washington, and preventing the laying out of a proposed stately and highly improved boulevard, extending from the Capitol to the Washington Monument. Col. Allen, reporting upon the proposed separate railway and highway bridges, says that these would have to be close together, or 1,200 ft. apart, to serve existing lines of travel; and this arrangement would make navigation in the river dangerous. He advocates a combined bridge, and a steel viaduct across the flats to be substituted for the present embankment. Gen. Wilson proposes certain amendments in the bill as presented to meet the above objections.

A TRACK ELEVATION ORDINANCE passed by the city council of Chicago on Feb. 19 provides for the elevation of the Chicago Terminal Transfer Ry. from Rockwell and 12th Sts. west to 45th Ave., 2½ miles. There are to be 14 subways, all of which are to be lighted by the railway company. The work is to be commenced by May, 1901, and completed in December, 1904. The work will cover the line shown just north of Douglas Park on the map of the track elevation system in our issue of Feb. 22, but it is reported that the company will refuse to accept the ordinance unless the requirement as to lighting the subways is struck out.

WATER-POWER BONDS are to be issued by the city of Chicago if an ordinance passed by the city council Feb. 19 is sustained by the courts. The amount is not to exceed $2,500,000, in 20-year $1,000 bonds at 4%, and is for the purpose of providing money with which to utilize the water power of the Drainage Canal. The city proposes to pay the Drainage Board $4 per HP. per year, delivered at the wheel, but a New York company is reported as being prepared to offer $6 per HP. The city has the first option on the power. The main object of the present ordinance, however, is to obtain a decision from the courts as to the city's authority to issue bonds in addiion to those now outstanding. It is provided that the ordinance is to be of no effect unless a contract is first made with the Drainage Board.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a head-on collision between two fast freights on the Baltimore & Ohio R. R., at Connellsville, Pa., on Feb. 24. One man was killed and eight injured.

THE CHICAGO DRAINAGE CANAL has again caused an accident in the Chicago River, similar to that recorded last week. The steamer "Amazonas" was being towed from the Indiana elevator at 18th St. to Halsted St., when the rope broke and the vessel was swung round by the current, the bow resting against a dock while the stern blocked the open draw of the bridge used by the Pennsylvania R. R. and Chicago & Alton R. R. The Drainage Board was notified and the bear-trap dam at the Lockport controlling works was raised so as to check the current, but the vessel could not be moved for some hours, during which time all traffic for the lines using the bridge had to be sent by a roundabout route. The "Amazonas" is 325 ft. long and 44 ft. beam; it had a cargo of 114,000 bushels of corn, giving it a draft of 16½ ft.

THE EIGHT-TRACK BRIDGE over the Chicago Drainage Canal at Campbell Ave. has again been the subject of controversy between the Drainage Board and the Scherzer Rolling-Lift Bridge Co., of Chicago, which has the contract. The difficulty has, however, now been settled, and the company has withdrawn its claims for extras, which it based upon the delays in the execution of its contract caused by certain changes in the design being required by the railways whose tracks will cross the bridge. The company's original contract was assigned to the A. & P. Roberts Co. (Pencoyd Iron Works), of Philadelphia, Pa. In consideration of this latter company finishing one-half of the bridge (four tracks) by Oct. 1, 1900, and the half (four tracks) by Dec. 15, 1900, the company is to be paid $75,000 in addition to the original price of $175,565. This information is furnished us by the Engineering Department of the Drainage Canal. The abutments for this great structure are nearly completed. The history of the bridge was reviewed in our issues of April 7, Aug. 25, Oct. 20 and Nov. 10, 1898.

THE KINZUA VIADUCT is to be replaced by a stronger structure, according to newspaper reports. This famous structure was built in 1882 to carry the New York, Lake Erie & Western R. R. over Kinzua Creek in McKean county, Pa., which flows through a gorge some 300 ft. below the level of the surrounding country. Its principal dimensions are as follows:

	Feet.	Ins.
Total length	2,050	0
Height above surface of water	302	0
Length of longest trestle bent	279	0
Width of towers c. to c. of bents	38	6
Longest span	61	0
Width c. to c. of trusses	10	0
Width over all	18	0
Weight of ironwork	1,400	tons.
Batter of posts	1 on 6	

In constructing the legs of the trestle bents of this bridge the well-known Phoenix column was employed.

A CIVIL SERVICE EXAMINATION for a mechanical draftsman will be held by the Municipal Civil Service Commission of New York city on March 12, 1900. Candidates will be examined in technical knowledge, experience, mathematics and handwriting. The technical paper will call for a knowledge of iron and steel construction and structural work in general, with particular reference to bridge construction. Candidates, who must be residents of the state of New York, should provide themselves at the time of the examination with drawing materials, with the exception of paper. For further details with reference to the subjects of the examination application should be made to F. G. Ireland, Chief Examiner. For application blanks and general information address Leo Phillips, Secretary, New Criminal Court Building, New York city.

THE REORGANIZATION OF THE CONSULAR service is proposed in House bill 1,026, now before Congress. In commenting on the bill, with the general purpose of which he is in hearty accord, Mr. Theo. C. Search, President of the National Association of Manufacturers, sets forth the positions of the association, as follows: Make as few changes as possible in the consular service; removals should only be made for demonstrated incapacity; fill vacancies by promotions, as far as possible; appoint solely on basis of personal qualifications for the position, without regard to political service; appoint only American citizens to any consular office.

A PACIFIC CABLE ROUTE is reported upon by Commander Hodges, U. S. N., as a result of his late survey in the U. S. S. "Nero." He reports an eminently satisfactory and practicable route for a submarine cable, from California to Honolulu, Guam, Midway Islands, Luzon and Yokohama. He would land the cable at Dingala Bay, on the east coast of Luzon, and at Tarafofo, on Guam. Between Guam and Midway Islands he made his deepest soundings, of 5,160 and 5,269 fathoms, and over this "deep" the cable must pass. The "Nero" steamed 29,283 knots, in making her survey, between April 22, 1899, and Feb. 11, 1900. The length of the line to Luzon would be 6,912 knots or sea-miles, divided as follows: San Francisco to Honolulu, 2,100 knots; to Midway Islands, 1,160 knots; to Guam, 2,280 knots; to Dingala Bay, Luzon, 1,372 knots; and from Guam to Yokohama, 1,342 knots. The distance from San Francisco to Yokohama, by way of Guam, would be 6,882 knots.

THE DEEPEST OCEAN TEMPERATURES RECORDED were taken by the U. S. Survey steamer "Nero" in sounding for the proposed submarine cable between Guam and Midway Islands. At a depth of 5,070 fathoms, or 30,420 ft., the temperature was 35.9° F., and at 5,101 fathoms, or 30,606 ft., it was 36° F. The previous deepest temperature record was taken by the British survey steamer "Penguin," in depths of 4,700 and 4,800 fathoms.

A SALT-WATER DETECTOR between the condensers and boilers of cruisers has been determined upon by the British Admiralty, to obviate a reoccurrence of the breakdown of the "Pegasus," last February. The condensers of this vessel leaked badly, and salt water in her boilers caused them to prime to such an extent that the cruiser was practically helpless for 16 hours off Cape Ushant. After temporary repairs to two boilers, she reached Plymouth. The detector referred to is practically an appliance for chemically testing the water during its passage between the condensers and boilers, at once indicating the admission of salt water.

BRITISH WAR TRANSPORTS, to date, says the New York "Journal of Commerce," amount to 214 steamships in number, with an aggregate of 1,050,350 tons. The largest of these is the White Star "Cymric," of 12,552 tons; with the "Afric," "Bavarian," "Medic," "Norseman" and "Winifredian" all exceeding 10,000 tons. In modern warfare, with ocean-space to be covered, the transportation of troops and supplies becomes a serious consideration, even in so "small an affair" as the Boer war was originally supposed to be.

A 6-CU. YD. DIPPER DREDGE FOR USE ON THE GREAT LAKES.

The material reduction in the cost of dredging on the Great Lakes during the past few years and the low price at which contracts are now being taken for dredging the waterways and harbors of these lakes have been due in a considerable measure to the use of larger and more powerful dredging machines. Some years ago a dipper dredge with a 3-cu. yd. dipper and 12 x 16-in. hoisting engine was considered a machine of very fair size,

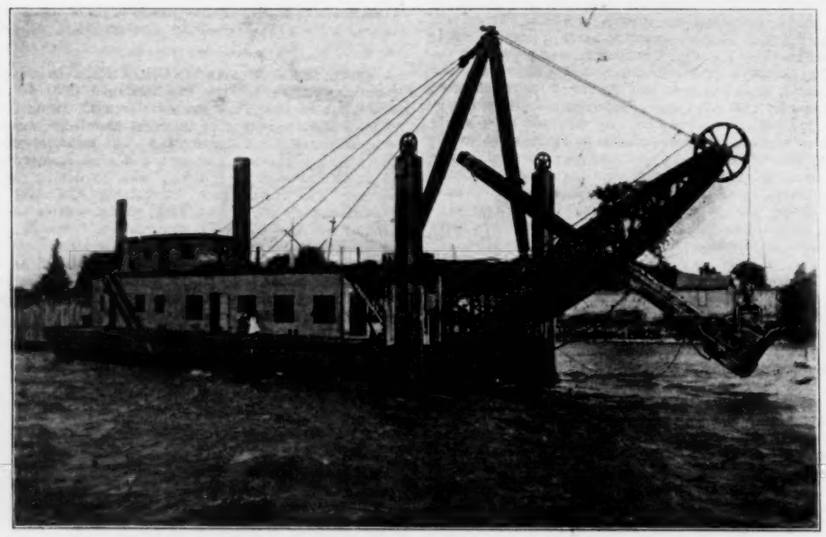

FIG. 1.—VIEW OF 6-CU. YD. DIPPER DREDGE BUILT FOR SERVICE ON THE GREAT LAKES.
Bucyrus Co., South Milwaukee, Wis., Builders.

but the last year has seen a dipper dredge constructed with a 10-cu. yd. dipper and 18 x 24-in. hoisting engine (Eng. News, July 13, 1899), and prominent builders of these machines prophesy that still greater capacities and dimensions will be employed in the near future. The dredge which is illustrated in the accompanying engravings does not reach these extremes in either direction, but is a good example of a modern dipper dredge of moderate power and capacity adapted to all around work, such as is being generally built for Great Lakes service. This machine was built for Mr. M. Sullivan of Detroit, Mich., by the Bucyrus Co., of South Milwaukee, Wis., which has furnished us the information from which the following brief description has been prepared.

Fig. 1 is a general view of the dredge ready for work. The hull is of wood and is 38 ft. wide, 110 ft. long, and 12 ft. deep, and is stiffened by two interior steel trusses. The boom is of steel and is 50 ft. long and carries a sheave of cast-steel 8 ft. in diameter. The A-frame is also of steel and is stepped upon the upper deck on top of the spud casings in such a way that when the dredge is "pinned up" the thrust of the A-frame is practically carried upon the spuds and the stresses resulting from it are not transmitted through the hull. The spuds are of Oregon fir, 36 ins. square, in one stick 50 ft. long, and are operated by wire ropes. There are two ropes to each spud and both ropes are attached to a drum, which is fitted with a powerful friction clutch and brake and is operated from the main engine. By this arrangement the entire power of the main engine is available for handling the spuds and "pinning up" the dredge. It is stated that although the spuds are so large and heavy, they can both be raised simultaneously with good speed and without difficulty, all the operations of throwing the clutches and brakes being performed by steam and being under complete control.

Like the great 10-cu. yd. dipper dredge previously mentioned, which was built by the Bucyrus Co., this dredge employs wire rope for hoisting instead of the more familiar chain hoist. The reasons for this modification are briefly summarized in a letter to us from the manufacturers as follows:

The chain system of hoisting answers very well for smaller dredges, but for high power and speed the hoisting chain becomes so large and cumbersome that its great weight and wear and tear are very serious items. Hoisting chains are also liable to break without warning and when such a chain breaks and leaves everything in the bottom of the river, it is a more troublesome matter to fish it up and reconnect it than in the old small dredges. Many experiments have been tried with wire rope substituted for chain in the usual way, using three parts; but the great wear on the rope used in this way, due to its speed of travel and frequent bending, causes it to wear out rapidly, and the expense for renewal is quite equal to the chain. The Bucyrus Co. has, therefore, adopted the principle (first used in a dredge built by them for Mr. John Kennedy, of Montreal), of a single-part wire rope, running at slow speed over very large sheaves, and to operate which the engines were geared up the necessary amount to give equivalent pull.

In the dredge illustrated the dipper is of 6 cu. yds. capacity. The hoisting rope is extra flexible plow steel, 2½ ins. in diameter, and the engines are 16 x 18 ins. with drum and gearing, as illustrated in Fig. 2. The hoisting gears, as will be seen, are double for the sake of strength. They are each 9 ft. in diameter by 11 ins. face, and drive a grooved drum between them of differential diameter, the small end producing a heavy strain at slow speed when the dipper is on the bottom and the rope rapidly climbing to a large diameter for the purpose of hoisting the dipper at speed. The effect of this is that the actual working speed of the dredge is something remarkable, and this speed is further aided by the freedom with which the dipper drops to the bottom and overhauls the wire rope. It will readily be seen that in the three-part chain dredge, the dropping of the dipper must necessarily be slow as it has to overhaul the long and heavy hoisting chain. In this case the weight of the rope is practically a negligable quantity and the dipper drops with absolute freedom and great speed, being controlled by a brake at the proper moment. To prompt the dipper to drop freely through the water without too great an impact, its door is made double with a part of its area opening inwards so that the dipper can pass through the water in its descent with slight resistance.

Referring more particularly to the operation of the hoisting engine and some of its special features the company writes as follows:

The hoisting drum is driven by two powerful band friction clutches of a special type, designed and patented by Mr. A. W. Robinson, M. Am. Soc. C. E. This type of clutch is one which has proved itself peculiarly adapted to the work and its operation has been very successful. Although carrying such a very heavy load, the power can be applied either gradually or instantly at the will of the operator. It is frequently necessary or desirable to slip the friction in order to ease the engines in case they become stalled. The two frictions are both actuated by one steam cylinder attached to the main frame, directly in line with the shaft. The movement of this cylinder is controlled by a very small slide valve and compensating links, so that the motion of the piston follows the motion of a man's hand in operating the lever. There is thus no necessity for any dash pot or oil cylinder, or other restraining mechanism, and there is perfect freedom from shock or jar in applying the friction. The two main pinions are keyed fast to the intermediate shaft, but only one of the hoisting gears is keyed to the main hoisting shaft. The object of this is to allow the gears to accommodate themselves so that each will take half of the load.

Another peculiarity in the design is that no space is occupied upon the shaft by sliding collars or other devices requiring end motion. The hubs of the main hoisting gears come close up to the bearings and the main hoisting drum fits snugly but freely between them, and is lined with phosphor bronze, so as to enable it to run loose upon the shaft. The main steam cylinder is connected to a plunger rod, entering the end of the shaft, which is hollow for the purpose. This plunger rod communicates motion also to the radius rods, actuating the toggles in the rim of the hoisting gears by means of sliding rack placed at suitable angle, and both radius rods are actuated simultaneously. The friction bands are 10 ins. wide, and are lined with hardwood blocks.

As indicated already the main engines are employed to operate the spuds in addition to hoisting the dipper. The swinging of the boom is accomplished by an independent engine and is by wire rope. Steam is furnished by a Scotch marine boiler 10 ft. in diameter and 6½ ft. long and having two corrugated furnaces. The dredge has been at work during the entire past season, it is stated, without any break down or mishaps of any kind.

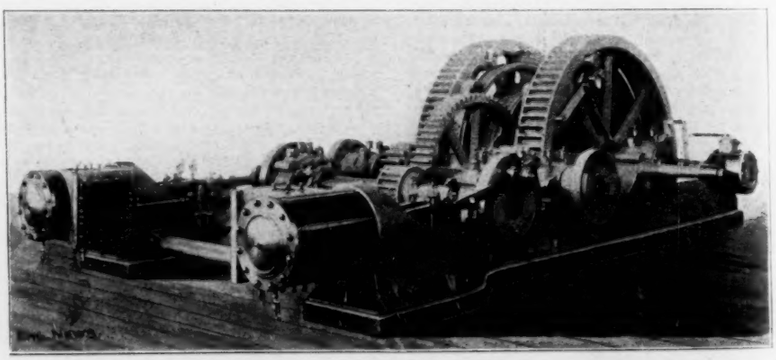

FIG. 2.—VIEW OF 16 x 18-IN. HOISTING ENGINES FOR 6-CU. YD. DIPPER DREDGE FOR GREAT LAKES SERVICE.

METHODS OF DETERMINATION OF LATITUDE, LONGITUDE AND SOLAR TIME IN RECONNOISSANCE SURVEYS.

By William S. Post.*

In reconnoissance work the engineer is frequently required to make use of methods and formulas which are only to be found scattered through separate works on navigation, surveying and astronomy. The purpose of the present compilation is to assemble together certain of these methods, formulas and references; especially such as have been found useful in topographic reconnoissance in Alaska; though these data are applicable anywhere for work of a similar character.

DEFINITIONS.

Astronomical.—Heavenly bodies are located by three systems of co-ordinates.

First System of Co-ordinates.—Altitude and Azimuth.—The origin is the place of observation. The primitive circle is the horizon, the horizontal plane tangent to the surface of the earth at the observer. The other axis is through the vertical line, which projected forms the zenith point of the observer. Angles around the horizon are the horizontal angles of surveying, and when the plane through the meridian line is taken as the plane of reference, they become the azimuths of astronomy. In astronomy and triangulation the south point is taken as zero, and angles of azimuth are measured from left around to right 360°. In surveying each quadrant is usu-

*Late U. S. Geological Survey, Washington, D. C.; now Engineer of Port America Co., P. O. Box 83, San Juan, Porto Rico.

ally specified as S. W., N. W., etc. Angles in the vertical plane are the vertical angles of surveying, or the altitudes of astronomy measured in each case from the horizon or level line.

Second System of Co-ordinates.—Declination and Hour Angle.—The origin is the center of the earth. The primitive circle is the terrestrial equator, and at right angles to it are meridian circles through the axis of the earth. The reference circle is the meridian plane through the place of observation; and hour angles are angles on either side of the meridian, as they would be obtained at the center of the earth. Declination is any angle at the earth's center measured in a meridian plane north and south from the equator, as zero.

Third System of Co-ordinates.—Declination and Right Ascension.—Differs from the second only in substituting for the plane through the local meridian a constant reference plane through a constellation.

The last two of these systems refer to the same point as origin, or the center of the earth. Since all the stars are practically at an infinite distance, it is assumed for purposes of computation that the "place of the observer" in the first system is identical with the center of the earth. The distance of the sun is so great, that for working purposes, this same assumption is true also in its case; but it is not true for the moon and planets, where the difference is not negligible ; and observations on them must first be reduced to the earth's center. As the three systems may be said to have origin and planes in common, the data of one can be transformed into those of the others, formulas for which are given in works on astronomy.

Terrestrial latitude and longitude fall under the second and third systems of co-ordinates. The latitude of a place is the angle at the earth's center between the equator and the place of observation; that is, it is identical with the declination of the zenith of the place. Longitude measures in hour angles the angle at the earth's center between a reference circle (usually the meridian of Greenwich), and the meridian of the place of observation.

NOTATION.

h = altitude.
z = 90° − altitude = zenith distance.
A = azimuth.
d = declination.
P = 90° − declination = Polar distance.
R.A. = right ascension.
L = latitude.
M = longitude.
t = hour angle.

LATITUDE.

Latitude is required in nearly every computation which follows, and naturally falls first in order of computation, although frequently not in the order of observation. It is best observed by taking the highest altitude of the sun at noon, or of stars as they successively pass the meridian; or, on Polaris at any time; or, by observing the sun or a star on the prime vertical. Roughly, one mile of northing or southing equals one minute of latitude, and latitude can often be supplied when not observed from former determinations and other data of survey. The angle required is an "altitude," that is a vertical angle from horizon or level up to the celestial object. Hence a sextant, a transit or any instrument carrying a vertical arc will do. The accuracy depends upon the least count of the arc and the sensitiveness of the level. An instrument reading to minutes may be expected to give latitude within one mile, etc.

I. Latitude by observation of the sun at noon. An altitude is taken to the upper or lower edge (called "limb") of the sun at its highest altitude; in practice this is done by commencing a few minutes before noon and observing successive angles until the sun transits and begins to descend. The highest angle is then taken for latitude computation. To deduce the latitude, the sun's declination at the time of observation must be first determined from the Nautical Almanac, or any solar Ephemeris published by the various instrument firms.

(a) To determine declination, take out from the tables

Declination at Greenwich, apparent noon for date	..°	..′	..″
Add algebraically $\left\{\frac{\text{longitude west from Greenwich}}{15}\right\}$ multiplied by diff. for 1 hr.		..′	..″
Declination at local apparent noon =	..°	..′	..″

North declination is considered +, and south −; west longitude is considered +, and east −. The sign of "difference for 1 hour" is given in the tables.

(b) To determine the latitude:

Altitude angle observed	..°	..′	..″
Subtract refraction, Table I.		..′	..″
True altitude sun's {upper / lower} limb	..°	..′	..″
Subtract / Add Semi-diam., for {upper / lower} limb observed		..′	..″
True altitude, sun's center	..°	..′	..″
Subtract algebraically declination (a) ±	..°	..′	..″
Co-latitude	..°	..′	..″
Subtract co-latitude from 90°	90°	..′	..″
Latitude*	..°	..′	..″

*"The American Ephemeris and Nautical Almanac" is published for each year by the Bureau of Equipment, Navy Department, Washington, D. C. Price, 50 cents. W. & L. E. Gurley, Troy, N. Y., and Riggs & Bro., 221 Walnut St., Philadelphia, Pa., publish abridgments of the "Nautical Almanac," useful in field work.

The longitude used in calculating declination (a) need not be accurately known. It is sufficient to roughly estimate from maps. Semi-diameter may be taken as 16′ when seconds of arc are not observed. For more accurate work the Nautical Almanac gives the semi-diameter for each day. For solar observations an assistant may hold a piece of smoked or colored glass in front of the eye-piece or objective; or better, a screen of colored glass is attached to the eye-piece, arranged so as to be turned out of the field when not required.

Example 1. Latitude.—On August 20, 1898, in approximate longitude 162° W., the altitude of the sun's lower limb at noon was found to be 41° 23′.

(a)	Declination Gr. app. noon, Aug. 20,	+ 12°	21′	59″
	Add $\frac{162°}{15}$ × (− 50″)	−	09′	..″
	Declinat'n local app. noon Aug. 20	+ 12°	12′	59″
(b)	Altitude angle observed	41°	23′	..″
	Subtract refraction, Table I.		01′	..″
	True altitude sun's lower limb	41°	22′	..″
	Add semi-diameter sun		16′	..″
	Altitude sun's center	41°	38′	..″
	Subtract declination (a)	+ 12°	13′	..″
	Co-latitude	29°	25′	..″
	Subtract co-latitude from 90°	90°	..′	..″
	Latitude	60°	35′	..″

Example 2. Latitude.—On March 4, 1898, in approximate Long. 95 W., the sun's upper limb was observed at noon by sextant to be 45° 58′ 20″.

(a)	Declination Gr. app. noon, Mar. 4.	— 6°	15′	31″
	Add $\frac{95°}{15}$ × (+ 58″)	+	6′	07″
	Declination, local app. noon, Mar. 4	— 6°	09′	24″
(b)	Altitude angles observed	45°	58′	20″
	Subtract refraction, Table I.		0′	56″
	True altitude sun's upper limb	45°	57′	24″
	Subtract semi-diameter sun		16′	09″
	Altitude sun's center	45°	41′	15″
	Subtract declination (a)	— 6°	09′	24″
	Co-latitude	51°	50′	39″
	Subtract co-latitude from 90°	90°	00′	00″
	Latitude	38°	09′	21″

II. Latitude by any star at its highest altitude or meridian passage.—A meridian can be obtained roughly by the needle or turning on the north star. Note any constellation, which may be near the meridian, and select a star from the star list. Observe the star until it reaches its highest altitude. The formula is the same as for the sun, but simpler, because a star has a constant declination and no diameter.

Computation for South Altitudes.

Altitude angle observed	..°	..′	..″
Subtract refraction		..′	..″
True altitude star	..°	..′	..″
Subtract algebraically declination	..°	..′	..″
Co-latitude	..°	..′	..″
Subtract co-latitude from 90°	90°	00′	00″
Latitude	..°	..′	..″

Computation for North Altitude.

Altitude angle observed	..°	..′	..″
Subtract refraction		..′	..″
True altitude	..°	..′	..″
Add declination	..°	..′	..″
Latitude + 90°	..°	..′	..″
Subtract 90°	90°	00′	00″
Latitude	..°	..′	..″

Example 3. Latitude.—At a certain place on a certain night, the following meridian altitudes were observed: Vega (α Lyrae) S. 66° 41′, Altair (α Aquilae) S. 36° 36′, and Polaris (upper culmination) N. 63° 17′.

	Vega.			Altair.		
Altitude observed	S. 66°	41′	00″	S. 36°	36′	00″
Subtract refraction	..	0′	25″		1′	19″
True altitude	66°	40′	35″	36°	34′	41″
Subtract declination	38°	41′	19″	8°	35′	56″
Co-latitude	27°	59′	16″	27°	58′	45″
Subtract from 90°	90°	00′	00″	90°	00′	00″
Latitude	62°	00′	44″	62°	1′	16″

	Polaris.		
Altitude observed	N 63°	17′	00″
Subtract refraction		0′	29″
True altitude	63°	16′	31″
Add declination	88°	45′	09″
Latitude + 90°	172°	1′	40″
Subtract 90°	90°	00′	00″
	62°	01′	40″

III. Latitude by observations of the North Star at any time, local time being known.—This method is given in the American Ephemeris and Nautical Almanac accompanied by the necessary tables for the reduction for each year.

IV. By observations of the sun or star on the prime vertical.—Chauvenet in a note on this method, says: "Since the star's declination is not required, this method has the additional advantage (which may at times be of great importance to the traveler), of being practicable without the use of the Ephemeris. This feature entitles this method to a prominent place in works of navigation." He gives it as follows:

We have $\frac{dz}{15\,dt} = \cos L, \sin A.$

If, then, we observe two altitudes near the prime vertical in quick succession, noting the times by a stop-watch with as great precision as possible, and denote the difference of the altitudes, or of the zenith distances by d z, and the difference of the times by dt, we shall have

$$\cos_{,} L = \frac{dz}{15\,dt} \operatorname{cosec} A.$$

The observation being made near the prime vertical, an error in the supposed azimuth A will have but small influence upon the result. If the observation is exactly in the prime vertical, or within a few minutes of it, we may put

$$\cos L = \frac{dz}{15\,dt}.$$

This exceedingly simple method, though not susceptible of great precision, may be very useful to the navigator, as it is available when the sun is exactly east or west, and, consequently, when no other method is practicable, and, moreover, requires no previous knowledge of the time or the approximate latitude, or of the star's declination."

Example 4.—1853, July 3, Prestel observed near the prime vertical the time required by the sun to change its altitude by a quantity equal to its apparent diameter. By observing with a sextant; first, the contact of the lower limb with its image in an artificial horizon, and then the contact of the upper limb with its image, the sextant reading being the same at both observations, namely, 30° 15′ 0″, he found

	Chronometer.
Contact of lower limb	4 h. 43 mins. 34.0 secs. p. m.
Contact of upper limb	4 h. 47 mins. 5.5 secs. p. m.
	3 mins. 31.5 secs.

The sun's diameter was 31′ 32″. Hence we have

d z = 31 mins. 32 secs. = 1.892 secs.	log.	3.2769
d t = 3 " 31.5 " = 211.5 "	ar. co. log.	7.6747
	log 1/15	8.8239
L = 53° 23.5′	Log. cos. L.	9.7755

The azimuth, however, was not exactly 90°, but about 88° 20′.

Hence we shall have, more exactly		9.7755
A = 88° 20′	log. cosec. A	0.0002
L = 53° 22.3′	log. cos. L	9.7757

It is evident that the method will be more precise in high latitudes than in low ones.

Latitude by Altitudes near the Meridian.—If, for instance, the noon observation of the sun has been prevented by clouds, an observation taken later may be reduced to meridian as follows; time from local apparent noon, that is, the hour angle being noted; if local time is not known, the azimuth of the reading must be taken:

(a) To reduce an azimuth A to corresponding

hour angle t, the observed altitude corrected for refraction being h.

$$\tan M = \text{co-tan h. cos A.}$$

$$\tan t = \frac{\tan A.\ \sin M.}{\cos (L - M)}.$$

L being taken approximately.

(b) Latitude.

$$\tan D = \tan d. \times \sec t.$$
$$\cos Y = \sin h.\ \sin D\ \operatorname{cosec} d.$$
$$L = D \pm Y.$$

AZIMUTH OR MERIDIAN LINE.

Azimuth may be obtained by observing Polaris at elongation, latitude being known; or by any star (including Polaris and the sun) at any time, latitude being known. The General Land Office publishes in its "Manual of Surveying Instructions," an excellent method and table for Polaris azimuths for any time, local time and latitude being known.

I. Polaris at Elongation.—At the instant of elongation we have

$$\sin A = \frac{\cos d.}{\cos L}.$$

The elongation may be determined by following the star with a transit until it reaches its fullest motion east or west, and accepting the greatest angle observed. Whether the elongation is east or west may be noted from the course of the star. Trautwine gives the following diagram by which

Fig. 1.

it can be determined in the field, from the fact that at elongation the star Alioth, of the constellation Great Bear, is nearly on a horizontal line with Polaris.

II. By any Star (including Polaris and the Sun) Latitude alone being known.—The further the star is from meridian, the more accurate the method becomes; except it must not be so low on the horizon as to have excessive refraction. The sun, for instance, is best observed between 8 and 10 o'clock in the morning, and between 2 and 4 o'clock in the afternoon.

(a) Method of Observing the Sun.—Two observations are made. The horizontal plate of the transit is clamped in a position where the sun is just entering the field. When the first limb contacts the vertical cross hair, the horizontal cross hair is contacted with the upper limb, and the vertical angle recorded. When the second limb contacts, the horizontal cross hair is brought to the lower limb, and vertical angle recorded. By diagram this may be shown as follows:

Fig. 2.

The horizontal angle reading will be the position of the sun's center corresponding to the mean of the two vertical angle readings. Some terrestrial object should be observed as an azimuth mark. If local time is also required the watch time of the successive contacts should also be carefully noted, and the mean taken. It must be noted roughly for computing declination. The record is then (for an afternoon observation):

	Angles—Horizontal.	Angles—Vertical.	Time
Sun's I. and lower limb	..° ..′	..° ..′	..h. ..m. ..s.
Sun's II. and upper limb	..° ..′	..° ..′	..h. ..m. ..s.
Sun's center (mean)		..° ..′	..h. ..m. ..s.
Correction for refraction.		..′	
Sun's center	..° ..′	..° ..′	..h. ..m. ..s.
Azimuth mark	..° ..′		

The formulas are

$$s = \tfrac{1}{2}(P + L + h);$$

$$\tan^2 \tfrac{1}{2} A = \frac{\sin (s - L) \sin (s - h)}{\cos s.\ \cos (s - P)}.$$

To find Polar Distance we require Declination at time of observation, computation being the same as before given.

Declination at Greenwich, apparent noon for date of observation		..° ..′ ..″
Add $\left\{\frac{\text{Long. w.fr.Gr.}}{15} \pm \text{hrs.,\&c., after or bef. noon}\right\} \times$ diff. for 1 hr.		..′ ..″
Declination time of observation		..° ..′ ..″
Subtract declination from 90°		90° 00′ 00″
Polar distance = P		..° ..′ ..″

For logarithmic computation we have,

P	..° ..′ ..″	
L	..° ..′ ..″	
h	..° ..′ ..″	
Sum 2	..° ..′ ..″	
S	..° ..′ ..″	sec.
s — h	..° ..′ ..″	sin.
s — L	..° ..′ ..″	sin.
s — P	..° ..′ ..″	sec.
Check sum ..	..° ..′ ..″	2
		log. tan ½ A =
		½ A = ..° ..′ ..″
Angle from true north to position at observation = A =		..° ..′ ..″

Bowditch's "Useful Tables," Bureau of Equipment, Navy Department, Washington, D. C., gives log, secants and cosecants, as well as log, sines and cosines, and is very convenient in this computation. If a table of secants is not available, it is only necessary to remember that log. secant = 10 — log. cosine. The "check sum" fails when s is smaller than h, L or P; but the computation remains the same, taking simply the difference of the quantities in each case.

Example 5. Solar Azimuth.—In Alaska, Lat. 62° 00′ 30″, Long. 151° 51′, July 5, 1898, the instrument set up with 0° 0′ of plate at the south end of needle. (A preliminary variation of 26° 10′ was used on the variation plate, that observed at a preceding station.) A sharp peak was observed as an azimuth mark, and the following observations were made on the sun for azimuth:

Point.	Angle—Horizontal.	Angle—Vertical.	Time
True south*	359° 56′ 00″		
Needle south†	0° 00′ 00″		
Azimuth mark	79° 07′ 00″		
Sun:			July 5.
(A) I. & lower limb.	300° 39′ 00″	39° 40′	21h. 09m. 45s
II. & upper limb		40° 30′	21h. 12m. 40s.
(B) I. & upper limb	314° 30′ 30″	44° 45′	July 5. 21h. 58m. 15s.
II. & lower limb		44° 24′	22h. 00m. 47s.
(C) I. & lower limb.	49° 02′ 00″	43° 20′	July 6. 2h. 37m. 26s.
II. & upper limb		43° 38′	2h. 39m. 56s.

*Determined below. †Var. 26° 10′.

	Azi. A.		Azi. B.		Azi. C.	
Greenwich declination, July 6	+ 22° 40′ 36″		+ 22° 40′ 36″		+ 22° 40′ 36″	
Add corr. (longitude and time)	— 1′ 49″*		— 2′ 01″†		— 3′ 10″‡	
Declination, time of observation	22° 38′ 47″		22° 38′ 35″		22° 37′ 26″	
	90° 00′ 00″		90° 00′ 00″		90° 00′ 00″	
P =	67° 21′		67° 21.5′		67° 22.5′	
L =	62° 00.5′		62° 00.5′		62° 00.5′	
h (corrected for refraction)	40° 04′		44° 33.5′		43° 28′	
Sum = 2 s	169° 25.5′		173° 55.5′		172° 51′	
S sec.	84° 42.7′	11.03542	86° 57.7′	11.27571	86° 25.5′	11.20513
s — h sin.	44° 38.7′	9.84677	42° 24.2′	9.82888	42° 57.5′	9.83330
s — L sin.	22° 42.2′	9.58656	24° 57.2′	9.62520	24° 25′	9.61634
s — P sec.	17° 21.7′	10.02025	19° 36.2′	10.02593	19° 03′	10.02446
	169° 25.3′ 2	20.48900	173° 55.3′ 2	20.75572	172° 51.0′ 2	20.67923
Log. tan ½ A =		10.24450		10.37786		10.33961
½ A =	60° 20′ 20″		67° 16′		65° 25′	
A =	120° 41′ 00″		134° 32′		130° 50′	
Azi from south	300° 41′ 00″		314° 32′ 00″		49° 10′	
Horizontal angle reading	300° 39′ 00″		314° 30′ 30″		49° 02′	
Plate reading of true south	359° 58′ 00″		359° 58′ 30″		359° 52′	
Average reading of true south	359° 56′.		Resulting variation		26° 14′.	

*(+ 10.1h. — 2.8h.) x — 15″. †(+ 10.1h. — 2h.) x — 15″. ‡(10.1h. + 2.6h.) x — 15″.

(b) The method is simplified for stars. The horizontal position of the observation being noted and a vertical angle taken, we first find the star's Polar Distance.

P = 90° — d.

Declination from star tables	..°	..′	..″
Subtract from 90°	90°	00′	00″
Polar distance	..°	..′	..″

The computation is the same as in Example 5.

Planets may be used, but have a constantly changing Declination, and have to be reduced in a manner similar to the Sun.

III. Azimuth by Polaris, at any Time, Local Time and Latitude being known.—The Manual of Surveying Instructions, General Land Office, Washington, D. C., gives (pp. 109-119) complete data for observing the North Star for meridian, as practiced in Land Survey.

TIME.

Watch or Clock Correction.—If,

T = the watch time.
T′ = the true time.
d T = the clock correction,

then,

$$T' = T + d\,T.$$

or,

$$d\,T = T' - T.$$

The watch correction will be + or —, according as the watch is slow or fast.

Rate of Watch.—The rate of the watch is determined by observing time on successive days at the same place. By dividing the difference of the watch corrections observed by the number of days between the observations, we get the rate per day, either increase of fastness, or slowness or decrease of fastness or slowness, which are indicated by the signs of the correction and of the rate. By formula, if we designate two observed times by T and T_0 the rate of r T is

$$r\,T = \frac{d\,T - d\,T_0}{T - T_0}.$$

and the true time T″ at any future date corresponding to a watch time T

$$T'' = T + d\,T_0 + r\,T\,(T - T_0).$$

Time Definitions.—Apparent local noon is the time of transit or meridian passage of the sun, at a given place. Apparent time is measured from Apparent noon. Mean local noon is the time of transit of a theoretical mean sun. The Mean day is the time between successive transits of the mean sun. The Civil day divides this day into an a. m. and p. m. period of twelve hours each, while the Astronomical day divides it into 24 hours, commencing at noon of the same Civil date. They are easily convertible; for example:

Astronomical time		Civil time
Feb. 11, 2 hrs.	=	Feb. 11, 2 p. m.
Feb. 11, 15 "	=	Feb. 12, 3 a. m.
May 31, 22 "	=	June 1, 10 a. m.

Astronomical time is used entirely in time computations, and it is convenient to record all time observations at once in this 24-hour time. The Equation of Time is the varying difference in time between Apparent and Mean time, and is given in the Solar Ephemeris. The Local Sidereal day is the interval between the successive transits of a point in the constellation Aries. It commences at this transit, and is divided into 24 hours. The sidereal time of transit of any star after the transit of Aries is its Right Ascension. The Civil and Astronomical day is 3m. 56s. longer than the sidereal day. Tables for their conversion into each other are given in the Nautical Almanac, Tables II. and III. Stars are catalogued by their Right Ascensions and Declination.

To Determine Local Mean Time. I. By transit of sun at noon.—An accurate meridian being es-

tablished and instrument alined upon it, the successive transits of the sun's first and second limb are noted by the watch.

Transit sun's I. limb.....	..h.	..m.	...s.
Transit sun's II. limb.....	..h.	..m.	...s.
2	..h.	..m.	...s.
Transit of center.....	..h.	..m.	...s.
± watch time of apparent local noon.			
Subtract algebraically equation of time	±	..m.	...s.
Watch time of local mean noon.....	..°	..′	..″
Watch, fast or slow on mean time.....	..°	..′	..″

Equation of time is given on Page I. of the Nautical Almanac for Greenwich, Apparent noon. A small correction must be made for Longitude (reduced to hours), by multiplying hours in W. Long. by "diff. for 1 hour," in last column. Adding to Greenwich equation of time we have local equation of time for date. Regard carefully sign of equation of time as given in precept at the head of the column. The equation of time is to be subtracted algebraically, that is, subtracted when precept is plus; added when minus.

II. By Equal Altitudes of the Sun Before and After Noon.—Sextant or transit. Does not require a meridian. This requires Tables in "Bowditch's Useful Tables," No. 37, or Chauvenet's "Practical Astronomy," Vol. II., No. iv.

T = time of apparent noon.
D d = increase of declination in 1 hr. (Page 1 "Nautical Almanac.")
h = sun's true altitude.
T_0 = mean watch time of two observations.
D T_0 = correction to this mean.

t = elapsed time.
A = tabular value for elapsed time.
B = tabular value for elapsed time.
Then

$$a = A.\ D\,d\ \tan L.$$
$$b = B.\ D\,d\ \tan d.$$
$$D\ T_0 = a + b.$$
$$T = T_0 + D\ T_0.$$

the equation of time subtracted from T will give watch time of local mean noon. The signs of quantities a and b must be carefully attended to. A and B are both given in the table; the sign of D d is in the ephemeris. L is + when north Latitude, and d + when north declination.

III. By Time Sight on Sun, at any Time, Latitude being known.—The vertical angles on Sun's upper and lower limb are taken, and the exact time of each observation. Then we have by taking the mean of each,

(a) Observed altitude of sun's center..	..°	..′	..″
Subtract refraction		..′	..″
True altitude sun's center	..°	..′	..″

occurring at date, ..h. ..m. ..s. (mean of observations).

(b) The formulæ are:

$$s = \tfrac{1}{2}\,(P + L + h),$$
$$\tan^2 \tfrac{1}{2}\,t = \frac{\cos s.\ \sin\,(s - h)}{\sin\,(s - L)\ \cos\,(s - P)},$$

t = hour-angle expressed in degrees, minutes and seconds.

(c) Observed time (mean of observat'n)	..h.	..m.	..s.	
Add, if before noon... / Subtract, if after noon } Hour-angle / 15	..h.	..m.	..s.	
Watch time of local apparent noon..	..h.	..m.	..s.	
Subtract algebraically eq. of time.	±	..m.	..s.	
Watch time of local mean noon	..h.	..m.	..s.	

Formula (b) requires the same quantities as the Solar Azimuth. The observations will be complete for either purpose if horizontal angle, vertical angles to upper and lower limbs, and corresponding times of contact be taken. To illustrate, take the observations for azimuth in Example 5, where the times are noted. P, L, h and s are the same.

Example 6. (Data from Example 5.)

(b)	A.	B.	C.
S cos...	84 42.7 8.96458	86 57.7 8.72438	86 25.5 8.79487
s—h sin...	44 38.7 9.84077	42 24.2 9.82888	42 57.5 9.83330
s—L cosec	22 42.2 10.41346	24 57.2 10.37481	24 25.0 10.38366
s—P sec...	17 21.7 10.02025	19 36.2 10.02593	19 03.0 10.02446
	19.24506	18.95400	19.03629
Log. tan ½ t =	9.62253	9.47700	9.51814
½ t =	22° 45′	16° 41′ 40″	18° 15′
t =	45° 30′	33° 23′ 20″	36° 30′
	3h. 02m.	2h. 13m.33s.	2h. 26m.

(c)	A. July	B. July	C. July
Observed time..	5, 21:11:12	5, 21:59:31	6, 2:38:41
Hour angle	3:02:00	2:13:33	2:26.00
Watch time of apparent noon	6, 0.13:12	6, 0:13:04	6, 0:12:41

Mean of observation apparent noon, July 6. 0h. 12m. 59s.
Equation of time (local) subtract ..... 0h. 04m. 33s.
Watch time of local mean noon ..... 08m. 26s.
Watch fast..... Correction = d T = — 8m. 26s.
Equation of time, Greenwich, July 6..... = 4m. 29s.
Longitude 10.1h. × .43 (difference of 1 hour) = 0m. 4s.
Local equation time ..... = 4m. 33s.

IV. By Transit of Star.—The instant of meridian passage of a star being noted by the watch, local mean time may be computed. For certainty in identification of star, its altitude should be care-

TABLE OF MEAN REFRACTION.

Barometer, 30 ins. Fahrenheit's Thermometer, 50°.

Apparent altitude.	Mean refraction.	Apparent altitude.	Mean refraction.	Apparent altitude.	Mean refraction.	Apparent altitude.	Mean refraction.	Apparent altitude.	Mean refraction.
° ′	′ ″	° ′	′ ″	° ′	′ ″	° ′	′ ″	° ′	′ ″
		9 30	5 35.1	15 0	3 34.1	25 0	2 4.4	42 0	1 4.7
0 0	36 29.4	35	5 32.4	10	3 31.7	10	2 3.4	20	1 3.9
1 0	24 53.6	40	5 29.6	20	3 29.4	20	2 2.5	40	1 3.2
2 0	18 25.5	45	5 27.0	30	3 27.1	30	2 1.5	43 0	1 2.4
3 0	14 25.1	50	5 24.3	40	3 24.8	40	2 0.7	20	1 1.7
4 0	11 44.4	55	5 21.7	50	3 22.6	50	1 59.8	40	1 1.0
5 0	9 52.6	10 0	5 19.2	16 0	3 20.5	26 0	1 58.9	44 0	1 0.3
5	9 44.0	5	5 16.7	10	3 18.4	10	1 58.1	20	0 59.6
10	9 36.2	10	5 14.2	20	3 16.3	20	1 57.2	40	0 58.9
15	9 28.6	15	5 11.7	30	3 14.2	30	1 56.4	45 0	0 58.2
20	9 21.2	20	5 9.3	40	3 12.2	40	1 55.5	20	0 57.6
25	9 14.0	25	5 6.9	50	3 10.3	50	1 54.7	40	0 56.9
5 30	9 7.0	10 30	5 4.6	17 0	3 8.3	27 0	1 53.9	46 0	0 56.2
35	9 0.1	35	5 2.3	10	3 6.4	10	1 53.1	20	0 55.6
40	8 53.4	40	5 0.0	20	3 4.6	20	1 52.3	40	0 55.0
45	8 46.8	45	4 57.8	30	3 2.8	30	1 51.5	47 0	0 54.3
50	8 40.4	50	4 55.6	40	3 1.0	40	1 50.7	20	0 53.7
55	8 34.2	55	4 53.4	50	2 59.2	50	1 50.0	40	0 53.1
6 0	8 28.0	11 0	4 51.2	18 0	2 57.5	28 0	1 49.2	48 0	0 52.5
5	8 22.1	5	4 49.1	10	2 55.8	20	1 47.7	49 0	0 50.6
10	8 16.2	10	4 47.0	20	2 54.1	40	1 46.2	50 0	0 48.9
15	8 10.5	15	4 44.9	30	2 52.4	29 0	1 44.8	51 0	0 47.2
20	8 4.8	20	4 42.9	40	2 50.8	20	1 43.4	52 0	0 45.5
25	7 59.3	25	4 40.9	50	2 49.2	40	1 42.0	53 0	0 43.9
6 30	7 53.9	11 30	4 38.9	19 0	2 47.7	30 0	1 40.6	54 0	0 42.3
35	7 48.7	35	4 36.9	10	2 46.1	20	1 39.3	55 0	0 40.8
40	7 43.5	40	4 35.0	20	2 44.6	40	1 38.0	56 0	0 39.3
45	7 38.4	45	4 33.1	30	2 43.1	31 0	1 36.7	57 0	0 37.8
50	7 33.5	50	4 31.2	40	2 41.6	20	1 35.5	58 0	0 36.4
55	7 28.6	55	4 29.4	50	2 40.2	40	1 34.2	59 0	0 35.0
7 0	7 23.8	12 0	4 27.5	20 0	2 38.8	32 0	1 33.0	60 0	0 33.6
5	7 19.2	5	4 25.7	10	2 37.4	20	1 31.8	61 0	0 32.3
10	7 14.6	10	4 23.9	20	2 36.0	40	1 30.7	62 0	0 31.0
15	7 10.1	15	4 22.2	30	2 34.6	33 0	1 29.5	63 0	0 29.7
20	7 5.7	20	4 20.4	40	2 33.3	20	1 28.4	64 0	0 28.4
25	7 1.4	25	4 18.7	50	2 32.0	40	1 27.3	65 0	0 27.2
7 30	6 57.1	12 30	4 17.0	21 0	2 30.7	34 0	1 26.2	66 0	0 25.9
35	6 53.0	35	4 15.3	10	2 29.4	20	1 25.1	67 0	0 24.7
40	6 48.9	40	4 13.6	20	2 28.1	40	1 24.1	68 0	0 23.6
45	6 44.9	45	4 12.0	30	2 26.9	35 0	1 23.1	69 0	0 22.4
50	6 41.0	50	4 10.4	40	2 25.7	20	1 22.0	70 0	0 21.2
55	6 37.1	55	4 8.8	50	2 24.5	40	1 21.0	71 0	0 20.1
8 0	6 33.3	13 0	4 7.2	22 0	2 23.3	36 0	1 20.1	72 0	0 18.9
5	6 29.6	5	4 5.6	10	2 22.1	20	1 19.1	73 0	0 17.8
10	6 25.9	10	4 4.1	20	2 20.9	40	1 18.2	74 0	0 16.7
15	6 22.3	15	4 2.6	30	2 19.8	37 0	1 17.2	75 0	0 15.6
20	6 18.8	20	4 1.0	40	2 18.7	20	1 16.3	76 0	0 14.5
25	6 15.3	25	3 59.6	50	2 17.5	40	1 15.4	77 0	0 13.5
8 30	6 11.9	13 30	3 58.1	23 0	2 16.4	38 0	1 14.5	78 0	0 12.4
35	6 8.5	35	3 56.6	10	2 15.4	20	1 13.6	79 0	0 11.3
40	6 5.2	40	3 55.2	20	2 14.3	40	1 12.7	80 0	0 10.3
45	6 2.0	45	3 53.7	30	2 13.3	39 0	1 11.9	81 0	0 9.2
50	5 58.8	50	3 52.3	40	2 12.2	20	1 11.0	82 0	0 8.2
55	5 55.7	55	3 50.9	50	2 11.2	40	1 10.2	83 0	0 7.2
9 0	5 52.6	14 0	3 49.5	24 0	2 10.2	40 0	1 9.4	84 0	0 6.1
5	5 49.6	10	3 46.8	10	2 9.2	20	1 8.6	85 0	0 5.1
10	5 46.6	20	3 44.2	20	2 8.2	40	1 7.8	86 0	0 4.1
15	5 43.6	30	3 41.6	30	2 7.2	41 0	1 7.0	87 0	0 3.1
20	5 40.7	40	3 39.0	40	2 6.2	20	1 6.2	88 0	0 2.0
25	5 37.9	50	3 36.5	50	2 5.3	40	1 5.4	89 0	0 1.0
9 30	5 35.1	15 0	3 34.1	25 0	2 4.4	42 0	1 4.7	90 0	0 0.0

Note on Table of Mean Refraction.

This table is given for average conditions, a barometer of 30 inches and thermometer of 50°, and is sufficiently accurate without correction for rough observations. For more precise computations, tables for reduction to barometer and thermometer are given in Chauvenet's "Spherical and Practical Astronomy," Vol. II., Table XIV.; and Bowditch, "American Practical Navigation," Tables 21 and 22.

LIST OF FIXED STARS. 1900.

(Abridged from the "Nautical Almanac.")

	Name of star.	Magnitude.	Right ascension h. m. s.	Declination ° ′ ″
α	Andromedæ	2.1	0 3 13.030	+ 28 32 18.01
γ	Pegasi (Algenib.)	2.8	0 8 5.135	+ 14 37 39.47
α	Cassiopeiæ (var.)	2.3	0 34 49.757	+ 55 59 20.20
β	Ceti	2.2	0 38 34.226	— 18 32 7.42
γ	Cassiopeiæ	2.3	0 50 40.146	+ 60 10 31.00
β	Andromedæ	2.2	1 4 7.831	+ 35 5 25.52
α	Ursæ Minoris (P'laris)	2.2	1 22 33.190	+ 88 46 26.61
β	Arietis	2.8	1 49 6.836	+ 20 19 9.36
γ	Andromedæ	2.2	1 57 45.497	+ 41 50 59.92
α	Arietis	2.1	2 1 32.058	+ 22 59 22.82
α	Ceti	2.6	2 57 3.069	+ 3 41 51.04
β	Persei (Algol) (var.)	2.3	3 1 39.575	+ 40 34 13.82
α	Persei	1.9	3 17 10.815	+ 49 30 19.36
α	Tauri (Aldebaran)	1.0	4 30 10.890	+ 16 18 30.03
α	Aurigæ (Capella)	0.1	5 9 18.035	+ 45 53 47.09
β	Orionis (Rigel)	0.3	5 9 43.897	— 8 19 1.40
β	Tauri	1.8	5 19 58.192	+ 28 31 23.09
δ	Orionis (var.)	2.3	5 26 53.849	— 0 22 23.06
α	Leporis	2.7	5 28 19.183	— 17 53 37.65
ε	Orionis	1.8	5 31 8.339	— 1 15 56.39
κ	Orionis	2.3	5 43 0.826	— 9 42 18.25
α	Orionis (var.)	0.9	5 49 45.472	+ 7 23 18.62
β	Aurigæ	2.0	5 52 11.037	+ 44 56 14.64
γ	Geminorum	2.0	6 31 56.122	+ 16 29 4.94
α	Canis Majoris	1.5	6 54 41.742	— 28 56 9.10
δ	Canis Majoris	1.9	7 4 19.484	— 26 14 3.54
α^2	Geminorum (Castor)	1.9	7 28 13.223	+ 32 6 29.17
β	Geminorum (Pollux)	1.2	7 39 11.867	+ 28 16 4.21
α	Hydræ	2.1	9 22 40.422	— 8 13 30.01
α	Leonis (Regulus)	1.3	10 3 2.841	+ 12 27 21.72
α	Ursæ Majoris	2.0	10 57 33.658	+ 62 17 27.33
β	Leonis	2.2	11 43 57.584	+ 15 7 51.93
γ	Ursæ Majoris	2.4	11 48 34.416	+ 54 15 2.79
γ	Corvi	2.7	12 10 39.727	— 16 59 11.71
β	Corvi	2.8	12 29 7.951	— 22 50 37.41
γ	Virginis (mean)	2.9	12 36 35.617	— 0 54 3.36
α	Virginis (Spica)	1.1	13 19 55.433	— 10 38 21.60
η	Ursæ Majoris	1.9	13 43 36.075	+ 49 48 44.29
η	Bootis	2.8	13 49 55.403	+ 18 53 56.20
α	Bootis (Arcturus)	0.2	14 11 6.000	+ 19 42 10.66
ε	Bootis	2.6	14 40 37.190	+ 27 29 44.52
α^2	Libræ	2.9	14 45 20.691	— 15 37 34.49
β	Ursæ Minoris	2.2	14 50 59.649	+ 74 33 51.05
β	Libræ	2.9	15 11 37.484	— 9 0 50.38
α	Coronæ Borealis	2.3	15 30 27.224	+ 27 3 4.00
α	Serpentis	2.7	15 39 20.507	+ 6 44 24.53
δ	Scorpii	2.6	15 54 25.130	— 22 20 13.71
δ	Ophiuchi	2.8	16 9 6.260	— 3 26 12.81
η	Draconis	2.8	16 22 38.175	+ 61 44 25.78
α	Scorpii (Antares)	1.2	16 23 16.479	— 26 12 36.39
ζ	Herculis	2.8	**16 25 55.219**	**+ 21 42 26.42**
ρ	Ophiuchi	2.8	16 31 39.090	— 10 21 52.55
η	Ophiuchi	2.5	17 4 38.521	— 15 36 3.99
α	Ophiuchi	2.2	17 30 17.537	+ 12 37 57.60
α	Lyræ (Vega)	0.2	18 33 33.162	+ 38 41 25.71
σ	Sagittarii	2.3	18 49 3.867	— 26 25 15.55
γ	Aquilæ	2.8	19 41 30.333	+ 10 22 9.95
δ	Cygni	2.9	19 41 51.005	+ 44 53 11.62
α	Aquilæ (Altair)	0.9	19 45 54.261	+ 8 36 14.68
α	Pavonis	2.1	20 17 44.281	— 57 3 19.83
γ	Cygni	2.3	20 18 38.355	+ 39 56 11.28
α	Cygni	1.4	20 38 1.361	+ 44 55 22.31
ε	Cygni	2.6	20 42 9.905	+ 33 35 44.04
α	Cephei	2.6	21 16 11.624	+ 62 9 42.51
β	Aquarii	2.9	21 26 17.716	— 6 0 40.32
ε	Pegasi	2.4	21 39 16.468	+ 9 24 59.10
α	Gruis	1.9	22 1 55.933	— 47 26 43.41
α	Pis. Aust. (Fomalhaut)	1.3	22 52 7.570	— 30 9 8.22
α	**Pegasi (Markab)**	**2.5**	**22 59 46.741**	**+ 14 40 1.83**

fully observed (which may be also used for Latitude determination). We have observed then,

Watch time of star's transit; date..... (Expressed in 24 hours' time.)	..h.	..m.	..s.
Alse altitude.....	.. °	.. ′	.. ″
From Ephemeris, P. II., column Sidereal time, or R. A. of mean sun, for date	..h.	..m.	..s.
Correction for hours of longitude west from Greenwich, Table III.*, add ...		..m.	..s.
Local R. A., mean sun for date...	..h.	..m.	..s.
From star table, R. A., star observed ...	..h.	..m.	..s.
Difference = elapsed sidereal time...	..h.	..m.	..s.
Cor. Table II.* for elapsed time, subtract		..m.	..s.
Elapsed solar time	..h.	..m.	..s.
Add or subtract from obs. watch time star's transit	..h.	..m.	..s.
Watch time of local mean noon...	..h.	..m.	..s.

*Tables II. and III. of "Nautical Almanac" are meant.

LONGITUDE.

Longitude is best determined by telegraph exchange of time. In field practice a good chronometer or watch alone can be used.

I. The difference in local mean time is the difference in Longitude. $M = (T_o - T)$, in which T_o and T are local mean times at two meridians T and T_o. If the longitude of either is known the other can be determined by observing "watch time of noon" at one point, carrying the watch to the other and again observing for local noon. The difference in watch time is the longitude expressed in time, that is, in hours, minutes and seconds. Multiply by 15 to get corresponding degrees, minutes and seconds. The rate of the watch must be known, and the correction applied.

II. By Sextant Lunar Distances.—The method is especially adapted for sextant, and is used at sea to check chronometers or recover Greenwich time in case of accident to chronometers. This, like the method III, does not require any knowledge of the longitude. It determines it absolutely, not relatively, as in method I., from the fact of the rapid motion of the moon with reference to other heavenly bodies. The computation of Lunar Distances is given in full in Bowditch's "Practical Navigator," pp. 133-141, accompanied by the necessary tables. The computation is somewhat tedious, and method III. will be found easier if a transit is to be had.

III. Longitude by Transits of Moon and a Star or the Sun. Latitude being known.—An accurate meridian being established, the transit of the moon's bright limb is observed. Either before or after, a transit of the sun or a star must be observed. The observed transit is reduced to transit of moon's center by adding or subtracting semi-diameter, expressed in time, p. IV. Nautical Almanac, according as the I. or II. limb is observed. The sun's transit is reduced to center by averaging the readings for I. and II. limbs, and correcting by equation of time, to watch time of mean local noon. By subtracting one from the other we get the difference in time (mean time units) between the sun and the moon, or "elapsed time."

From p. II. of the Nautical Almanac we have the Sidereal Time, or R. A. of Mean Sun at Greenwich. Making the proper correction for longitude (assuming a rough longitude) we get the local R. A. of Mean Sun. Adding or subtracting elapsed time (corrected to sidereal units) we have R. A. of Moon, which we denote a_1. Referring now to the hourly Ephemeris of the Moon given in the Nautical Almanac, we have:

(x'' will be positive when D a is decreasing and negative when D a is increasing).

$$x = x' + x''.$$
$$T_1 = T_0 + x.$$

T_1, which is the Greenwich time of the moon observation expressed in mean time units, is now converted into the corresponding Greenwich sidereal time = H_1. The difference between H_1 and a_1, is Longitude from Greenwich = M; $M = H_1 - a_1$

Example 7.—In Latitude 59° 48′, roughly, 10.5 hours west longitude from Greenwich, the following observations were made September 11, 1898, a watch with inappreciable rate being used:

Transit of moon's II. limb at Sept. 10..	21h.	05m.	28s.
Mean of transits sun's I. and II. limbs, Sept. 11.	0h.	12m.	29s.
Computation.			
Transit sun's center .....Sept. 11.	0h.	12m.	29s.
Local equation of time		3m.	39s.
Watch time, mean local noon, Sept. 11.	0h.	16m.	08s.

FIG. 2.—TYPICAL SECTIONS OF SEAMLESS RIBBED TUBES.

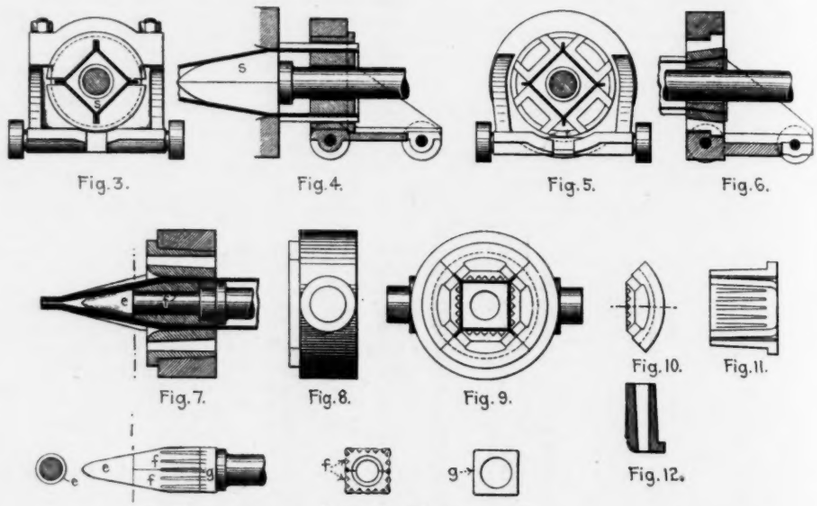

Fig. 3. Fig. 4. Fig. 5. Fig. 6.

Fig. 7. Fig. 8. Fig. 9. Fig. 10. Fig. 11.

Fig. 12.

Fig. 13. Fig. 14.

FIGS. 3 TO 14.—DETAILS OF MANDRELS AND DRAW PLATES FOR DRAWING SEAMLESS RIBBED TUBES.

Transit moon's II. limb.....Sept. 10.	21h.	05m.	28s.
Semi-diameter 14′ 53″, subtract.....			59s.
Watch time, transit moon's center..	21h.	04m.	29s.
Elapsed time (mean time units).....	3h.	11m.	39s.
Corr. Table III. "Nautical Almanac"...			32s.
Elapsed sidereal time	3h.	12m.	11s.
R. A. sun Greenwich .....Sept. 11.	11h.	22m.	07s.
Corr. Table III. for Long. 10.5h.....		1m.	43s.
Local R. A. sun. .....Sept. 11.	11h.	23m.	50s.
Subtract elapsed sidereal time.....	3h.	12m.	11s.
R. A. moon = a_1 .....Sept. 11.	8h.	11m.	39s.
..h. ..m. ..s. = T_1 = required mean Greenwich time, corresponding to a_1 =.....Sept. 11.	8h.	11m.	39s.

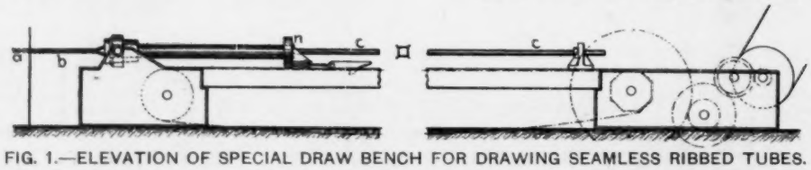

FIG. 1.—ELEVATION OF SPECIAL DRAW BENCH FOR DRAWING SEAMLESS RIBBED TUBES.

T_1 = mean Greenwich time required corresponding to a_1	..h.	..m.	..s.
..h. ..m. ..s. = To = Greenwich hour of table immediately preceding and corresponding to R. A.			
a_0 = ...	..h.	..m.	..s.
$a_1 - a_0$ = ...			..s.

D a = increase in R. A. in 1 minute of mean time To.
d a = increase of D a in 1 hour.

To find T_1 (Chauvenet's "Practical Astronomy")

$$x' = \frac{60\,(a_1 - a_0)}{L\ a}; \qquad x'' = \frac{x'^2}{7{,}200} \cdot \frac{d\ a}{D\ a};$$

Sept. 11. 7h. 00m. 00s. = T_0 = preceding Gr. hour from Ephemeris, corresponding to a tabular R. A. = a_0 = ...Sept. 11. 8h. 10m. 43s.

$a_1 - a_0$ = ... 56s.

From Ephemeris D a = 2.0154s.
From Ephemeris d a = .0025s.

$$x' = \frac{60 \times 56}{2.0154} = 1{,}667.2\text{s}.$$

$$x'' = \frac{(1{,}667.2)^2}{7{,}200} \cdot \frac{.0025}{2.0154} = +\ 0.5\text{s}.$$

$x = x' + x'' = 1{,}668\text{s}.$

$T_1 = T_0 + x.$

T_1 = Sept. 11.	7h.	24m.	28s.
Greenwich R. A. mean sun.....Sept. 11.	11h.	22m.	07s.
Corr. Table III. for 7h. 24m.		1m.	13s.
H_1 = ...Sept. 11.	18h.	47m.	48s.
a_1 = ...Sept. 11.	18h.	11m.	39s.
M = ...	10h.	36m.	09s.

IV. If we have the Latitude and Longitude of a point P and an Azimuth on a second point P′ and at P′ observe the Latitude, we can compute the approximate Longitude of P′ by the following formula:

$$M' = M + \frac{u \cdot \sin A}{\cos L'};$$

For P′ north of P

$$\sin u = \frac{\sin (L' - L)}{\cos A};$$

For P′ south of P

$$\tan u = \frac{\tan (L - L')}{\cos A}.$$

u is expressed in seconds of arc; L, M and A are Latitude, Longitude and Azimuth at P, L′, M′ are Latitude and Longitude at P′.

A MACHINE FOR DRAWING SEAMLESS STEEL TUBES WITH LONGITUDINAL RIBS.

A form of seamless steel tube having longitudinal exterior ribs to give it strength against flexure has recently been extensively used in Germany for various purposes where riveted or welded tubes or built-up hollow columns and poles have usually been employed. These tubes are manufactured by the Duisberger, Eisen & Stahlwerke, of Duisberg-on-the-Rhine, Germany, which has patented the construction in America, where it is being handled by Messrs. Riensberg & Von der Werra, of New York city. Aside from its apparent structural advantages in certain respects this tubing is of particular interest for the methods adopted in its manufacture. As described in the patent specifications, the process is as follows:

Hollow bodies of malleable material, cast or otherwise produced, and having pieces connected therewith for producing the flanges or ribs, after having been pressed and stretched into flat bands in a rolling mill or under the steam hammer, are opened out at one end by hand, and by suitable devices in such manner that the band-formed piece can be drawn on a suitable strong draw-bench over our improved, specially-constructed, fixed mandrel, which at its rear end has the form of the inner profile and works in conjunction with our improved, specially-formed draw-plate, which has in its back cross-section the outer profile of the beam or pillar.

Fig. 1, taken from the patent specifications, shows quite clearly the construction of the draw

bench, and Fig. 2 shows some of the various sections of tubing which are produced by it. Fig. 3 is a rear elevation of the carriage (n, Fig. 1), and Fig. 4 is a longitudinal section showing the mandrel in elevation and the draw plate in section

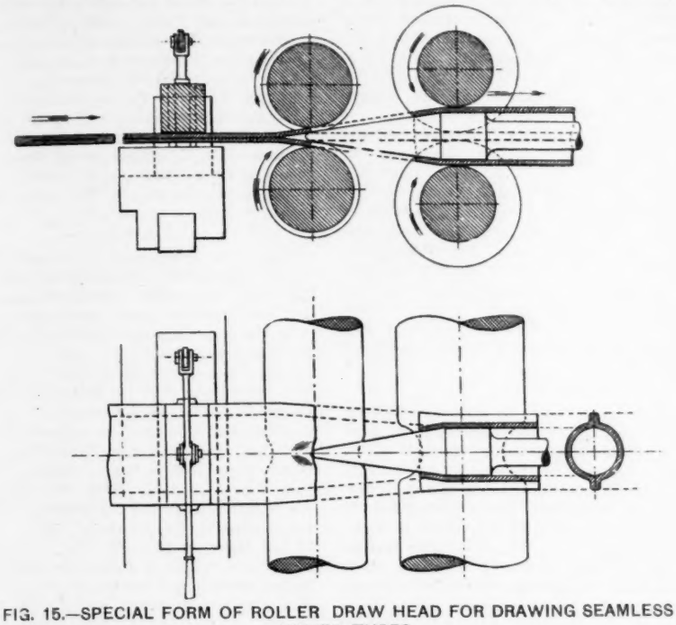

FIG. 15.—SPECIAL FORM OF ROLLER DRAW HEAD FOR DRAWING SEAMLESS RIBBED TUBES.

and also one method of locking the end of the tube being worked to the carriage. Figs. 5 and 6 are similar views to Figs. 3 and 4, showing the preferred arrangement of holding the end of the tube being drawn. Figs. 7, 8 and 9 are elevations and sections showing the preferred forms of draw plate and mandrel, of which Figs. 10 to 14 are details. Another form of draw head construction in which rolls take the place of the usual draw plate is shown in sectional elevation and plan by Fig. 15.

Turning now to Fig. 1, the flattened hollow ingot b will be seen coming from the furnace a and passing onto the mandrel, which consists of a rod or shaft c, and a long extended head s (Fig. 4). The mandrel head has its front end formed so as to constitute an opening wedge, while the rear end has a parallel exterior, as shown by the drawings. This wedge-shaped fore part, when designed to produce tubes of considerable size, consists of the pointed wedge or opener e (Fig. 7), and the stretcher or expander f. The draw plate for such forms of tubes as can be produced by a single operation, or drawing, is constructed as a long extended funnel. In the interior of this funnel, and parallel with the axis of the piece to be drawn, are raised round-shaped ribs which are gradually widened out and flattened from front to rear, and finally run into a plane surface corresponding to the walls of the finished tube. These ribs, the cross-section of which is continually altering along the longitudinal axis of the draw plate, are arranged in such a manner that the material of the walls of the tube being drawn, which has been opened and widened to some extent by the wedge point e and the expander f, is at first only slightly grooved by the forward part of the ribs on the mandrel head, and then pressed sidewise and distributed by the following broadened parts of the ribs in such a manner that the band-shaped piece being worked will, during its drawing over the mandrel and through the draw plate, only gradually assume a form similar to the rearmost cross-section of the draw plate and mandrel head. By this arrangement, it will be observed that no further shaping of the tube takes place at the rear parts of the draw plate and mandrel head, but only a compression and finishing, or smoothing, of the already-shaped work, similar to the ordinary drawing process.

The preceding description of the action by which the tube is shaped refers, of course, to the form of draw head in which the regular mandrel and draw plate are employed. Where the draw plate is replaced by rollers, as shown by Fig. 15, the action differs in a manner which will be clearly understood by the drawings. The particular rolls shown are designed for drawing a tube of a circular cross-section with two diametrically opposite exterior ribs, but they may be designed to draw various other sections of tube.

Fig. 16.—Pole Made of Seamless Ribbed Tube for Supporting Electric Railway Overhead Trolley Wire.

By studying what has been said in connection with the drawings, the construction and operation of the tube drawing machinery will, we think, be reasonably clear. As manufactured by the Duisberger, Eisen & Stahlwerke, the tubes are drawn from flattened hollow ingots of Siemens-Martin steel, having a breaking strength of from 57,000 lbs. to 71,000 lbs. per sq. in., and an elongation of from 20% to 30%. The tubes are made in lengths up to 33 ft., and in all diameters up to about 20 ins., and the form most extensively manufactured is that with a circular cross-section with two diametrically opposite exterior ribs. Where greater lengths of tube are required than can be had with a single tube, two or more tubes are connected by special joints.

We are informed by the American agents for these tubes that they have been used in Germany for columns in bridge and building work, stanchions for ships, pipes for steam, water, gas, etc., and for poles for electric trolley wires, telegraph and telephone wires, etc. Fig. 16 shows an application of the common form of tube to the construction of poles for carrying trolley wires for electric railways. The adaptability of the construction to ornamentation is shown by this illustration, which also shows the valuable office of the exterior ribs in strengthening the pole to resist the bending strain produced by the weight and pull of the trolley wire. A similar disposition of the ribs in the plane of the strain is employed where the tubes are used for overhead pipe lines, thus reducing the number of supports required. Various other uses in which the increased flexural strength due to the exterior ribs is advantageous will suggest themselves to the reader.

The advantages claimed for these ribbed tubes as compared with ordinary seamless tubes is their lighter weight for the same flexural strength, owing to the possibility of placing the ribs in the plane of the strain. As compared with riveted or built-up tubes or hollow columns, they are claimed to be much lighter in proportion to their strength, and therefore to be less expensive. It is also claimed that, being seamless, they are less liable to suffer from corrosion than riveted built-up sections. For the information from which this description has been prepared we are indebted to Messrs. Riensberg & Von der Werra, of New York city, the American agents for the German manufacturers.

THE INCOME ACCOUNT OF RAILWAYS for the year ending June 30, 1899, is made the subject of a preliminary report by the Interstate Commerce Commission. The summary shows that for 691 lines, representing 185,246 miles of line, the returns for 1899 were as follows: Passenger service, $360,227,319; freight service, $913,358,488; other earnings from operation, $33,611,921; unclassified earnings, $55,756. These aggregate total gross earnings of $1,307,253,484; deducting from this operating expenses of $852,428,105, the net income from operation equals $454,825,379, or 34.79% of total earnings. From this net income must be paid interest on bonds, taxes, permanent improvements charged to income account, dividends and other analogous charges. With all charges paid, the surplus from operation account, for the year ending June 30, 1899, figures at $50,768,209; in June 30, 1895, the corresponding summary showed a deficit of $31,075,030; a difference indicating the financial betterment of railways since 1895.

THE MATERIAL GROWTH OF THE UNITED STATES was the subject of an address lately delivered by the Secretary of the Treasury before the National Association of Merchants and Travelers. His grouping of comparisons between 1870 and 1899 tell their own story, and these may be tabulated as follows:

	1870.	1899.
Spent on public schools	$37,732,556	$123,809,412
Newspapers and periodicals, No.	5,871	21,178
Post office receipts	$19,772,221	$95,021,384
Telegrams sent	9,157,646	76,085,175
Cost of transportation, per ton-mile	1.94 cts.	0.75 cts.
Cotton mill consumption, bales.	857,000	3,632,000
Raw silk imported, lbs.	583,589	11,236,846
Crude rubber imported, lbs.	9,624,698	51,063,096
Pig iron production, tons	1,665,179	11,773,934
Steel production, tons	68,750	8,932,857
Export of iron and steel manufactures	$11,002,902	$93,716,031
Coal production, tons	32,863,000	196,405,953
Petroleum, gallons	185,000,000	2,325,000,000
Foreign imports	$435,958,408	$697,148,498
Foreign exports	$392,771,768	$1,227,023,302
Export of manufactures	$68,279,764	$338,667,794

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ADVERTISING RATES: 20 cents a line. Want notices, special rates, see page XXI. Changes in standing advertisements must be received by Monday morning; new advertisements, Tuesday morning; transient advertisements by Wednesday morning.

The prospects that New York will undertake the $60,000,000 Erie canal enlargement recommended by Governor Roosevelt's advisory committee* do not improve with the lapse of time. One cardinal feature of the plan—the assessment of the cost of the work upon the counties bordering the canal—has received a black eye; for the Attorney-General has rendered an opinion that such a distribution of a tax would be unconstitutional. With this feature of the project thwarted, all parts of the state off the line of the canals will be practically solid in their opposition, and the political leaders are taking this fact into account. As we predicted some weeks ago, the rulers of the dominant political party in the state are loth to take the responsibility for so great an expenditure, which is certain to meet with great opposition, and which must be submitted to a popular vote for approval. Thus far, the bill for the proposed canal enlargement has not even been introduced in the legislature; and the chances for the successful passage of any bill so strongly opposed as this is likely to be diminish as the day of adjournment approaches.

Recent reports are that the legislature will solve the problem by an appropriation which will provide for complete surveys and new estimates for the 1,000-ton barge canal recommended by Gen. Greene and his associates. The tone of public comment, since the report of these gentlemen was presented, indicates that the people are not yet satisfied that the proposed $60,000,000 enterprise might not prove a $100,000,000 job before the task was completed.

It is to be remembered that the members of the advisory canal committee served not only without pay, but without an appropriation. Where the funds came from to pay for the engineering work which it conducted, we do not know; but as a matter of fact, on its own showing, these estimates were compiled by three engineers in three or four months' work. They were approved by two other engineers, who gave their services gratis out of pure patriotism. Now we do not presume to question the fidelity and ability of the engineers who did this work, or of the able engineers who were members of the committee; but it really seems a rather inadequate basis on which to found estimates for a public improvement of such enormous cost, and one where the public confidence in the reliability of estimates has been already so seriously shaken.

It is true that the estimating engineers had the use of the surveys and records of the State Engineer's office and of the U. S. Deep Waterway Commission; and we are entirely ready to believe that their estimates are more deserving of credence than those of any previous body who have investigated this subject. Something more than this is needed, however, to satisfy the public; and if the legislature does not want to place Governor Roosevelt's barge canal project entirely on the shelf, it will very likely provide for a new examination of the project, and a new set of surveys and estimates.

*Eng. News, Feb. 1 and Feb. 8.

Apropos of the work of the above committee, is there any other profession (unless it be such an avowedly altruistic one as the clerical) which does so much unpaid work as the engineering profession? The whole question on which Governor Roosevelt requested his advisory committee to report was, in nine-tenths of its aspects at least, a question of engineering. It ought to be just as much the function of engineers of the highest standing and largest experience to render an opinion on such questions for a liberal fee, as it is the function of the lawyers of greatest reputation to render an opinion on the most knotty points of constitutional law.

This is the "ought to be." The actual state of affairs may be indicated by a contrast. Judge Edwin Countryman in 1898 examined the evidence taken by Governor Black's canal investigating commission, and rendered an opinion declaring the officials responsible to be culpable and liable to criminal prosecution. For this service his fee was, to the best of our recollection, in the neighborhood of $20,000. The succeeding administration submitted to a firm of New York attorneys the question whether such a prosecution if instituted would probably be successful. A negative opinion was rendered, for which another $20,000 fee was paid. Now comes the State of New York and asks what it ought to do about its canals; and it obtains the advice of such able engineers as Gen. Greene, Major Symons, W. B. Parsons and Theodore Cooper without the payment of a single penny.

It would be interesting to know how many cities could equal or outrank Hartford, Conn., in the number of leaking fixtures connected with its water-works system. In common with many other New England cities, Hartford found itself very short of water early this winter. It instituted a thorough inspection of water fixtures and has been rewarded by discovering 1,781 water closets leaking and 156 running; also 1,260 faucets leaking and 34 running; all between Jan. 2 and Feb. 13, inclusive. We venture to say that had all the consumers involved been metered these 3,231 instances of waste would have been greatly reduced in number. Even if all the waste continued without check, meters would make those who were responsible for the waste pay for it.

The waste at Hartford is all the worse because resort was had to the polluted Connecticut River to make good the deficiency in the supply. On at least one previous occasion when this was done the typhoid mortality was markedly increased as an apparent consequence.

Very likely some of the faucets found running were so left to guard against the freezing of improperly protected plumbing. The influence of cold weather and the accompanying running faucets is well known to water-works officials, but it has just been illustrated anew at Jersey City. On Jan. 26 the water used and wasted was 30,891,000 gallons. The next day was colder, according to the Jersey City "Journal," and the consumption rose to 34,578,000 gallons. It fell a little on Jan. 28, but kept up pretty well until Feb. 1, when it went to 35,417,000 gallons, while on Feb. 2 (Friday) it reached 37,106,000 gallons. Cold weather and faucets running to prevent freezing are the explanation given for this great increase of consumption and waste. And the increase came at a time when the officials of the city were racking their brains to discover some means of raising money to pay $285,000 arrearages for water supplied by the East Jersey Water Co., that company now supplying the city at so much per million gallons. No wonder that Mr. Chas. Van Keuren, Chief Engineer of the Street and Water Commissioners, has recommended a universal meter system for Jersey City, as noted in our issue of Feb. 15.

The sewer commissioners of Saratoga Springs, N. Y., deserve high praise for the stand they have taken on water waste; and the water commissioners also deserve credit for hearty co-operation with the sewer commissioners, although the present dilemma would not exist had past water boards taken proper steps to keep down the waste. The situation is this: On March 30, 1899, Governor Roosevelt, after an investigation by the State Board of Health, signed an order for the abatement of certain nuisances in and about Saratoga Springs within stipulated periods. (See news note, p. 225, Eng. News, April 13, 1899.) The terms of the order virtually required the construction of sewage purification works by April 1, 1900. As we stated in our issue of July 13, 1899, the new board of sewer commissioners found the problem of purification entirely beyond the financial means of the village unless the water waste could be cut down. In the winter, 400 to 500 gallons a day were pumped for each actual consumer, and the average daily consumption and waste for the whole year, it is said, was then exceeded by but few municipalities in the world. The sewer commissioners brought the matter to the attention of the water commissioners, and a joint committee was appointed from the two boards to consider the problem. As a result, the speedy introduction of meters was recommended, and accordingly 700 were bought. On Feb. 6, the sewer commissioners reported to the village trustees that they were not yet prepared to submit plans, even, for the sewage purification works, supposed to be ready on April 1. The water commissioners had run out of funds when only 400 of the 700 meters had been set, and some 1,500 meters in all were needed to properly conserve the supply and stop excessive waste. The sewer commissioners felt that until the water consumption and waste could be "cut down at least two-thirds, and be permanently held there," they would not be warranted in planning purification works, especially as the only land available for intermittent filtration would be insufficient to treat even 1,000,000 gallons a day, some of which would have to be pumped to the disposal area. The sewer commissioners make the suggestion that the sewer and water boards should be consolidated, which would seem to be a wise plan, where the relation between the two are so intimate as in this case.

Besides the greatly increased flow of water due to water waste, the sewers now receive street drainage and brook water, which sometimes, the commissioners state, brings the total flow in the outlet sewer up to 20,000,000 gallons a day. This surface water, they say, can be easily diverted, but they fear they cannot begin the necessary work, under the statute, until they have made complete plans for sewage disposal, which, in turn, are waiting on the reduction of water waste.

No better arguments for keeping down water waste and for taking a long look ahead before adopting the combined sewerage system, could well be cited than those brought out by the situation at Saratoga Springs. The case would be stronger, if all the water there had to be filtered as well as pumped, and if all the sewage required pumping, as well as purification; but it is bad enough as it is.

We are indebted to Mr. L. H. Cramer, Chairman of the Sewer Commisssioners, for a copy of the special report of the commissioners, dated Feb. 6, 1900, which also contains the special joint com-

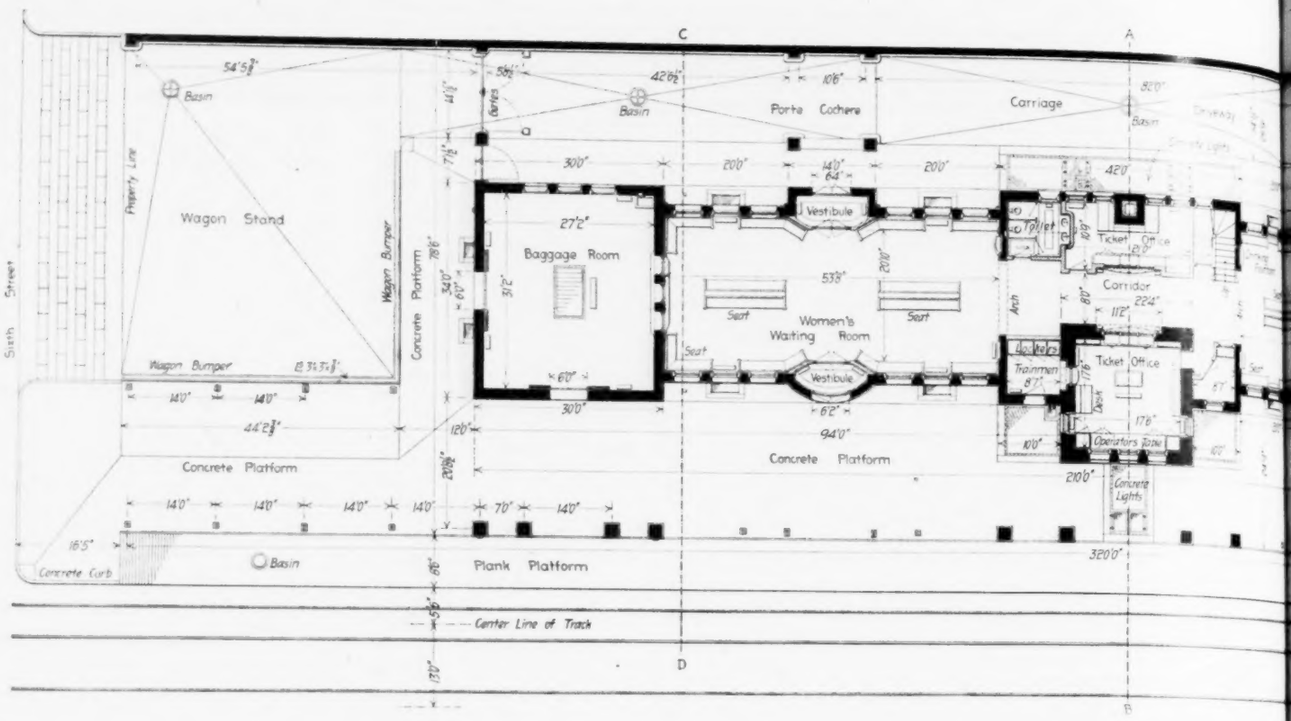


FIG. 1.—PLAN OF FIRST FLOOR.

FIG. 4.—PERSPECTIVE VIEW OF STATION.

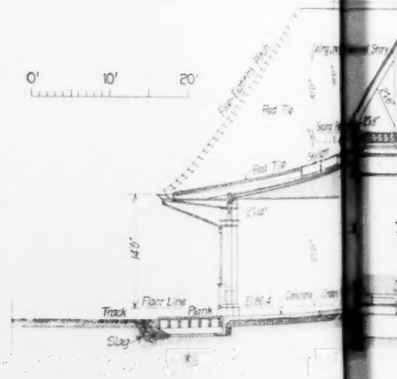
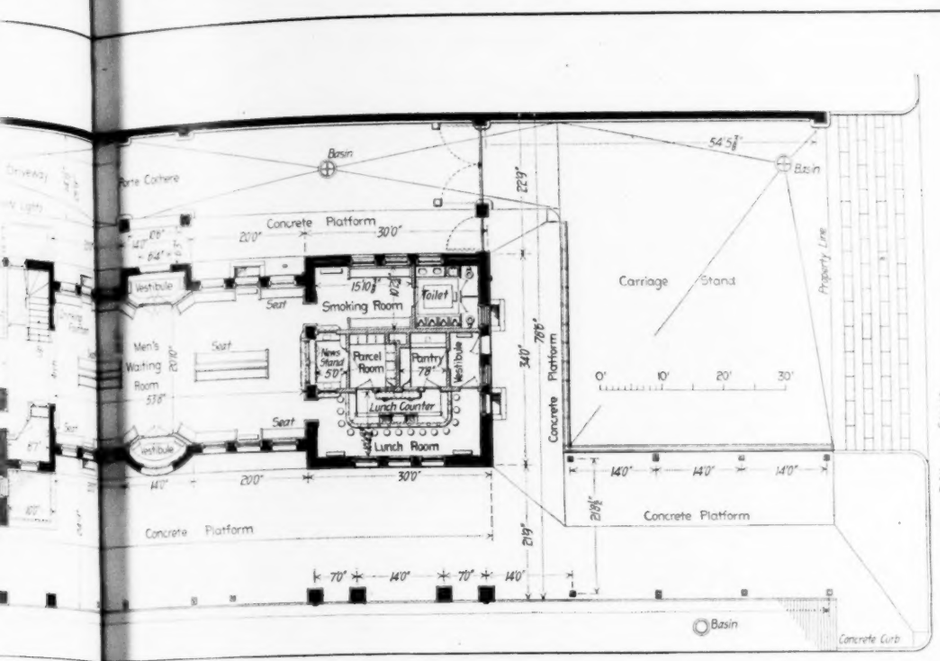
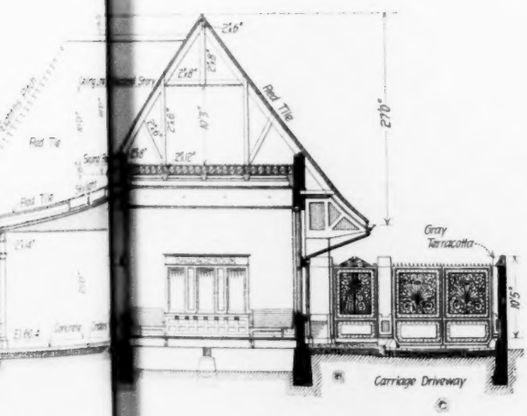


FIG. 2.—CROSS-SECTION C—D THROUGH W

UNION PASSENGER STATION, AT

Francis P. Bacon, Ill. Central R.R., Architect.





WOMEN'S WAITING-ROOM.

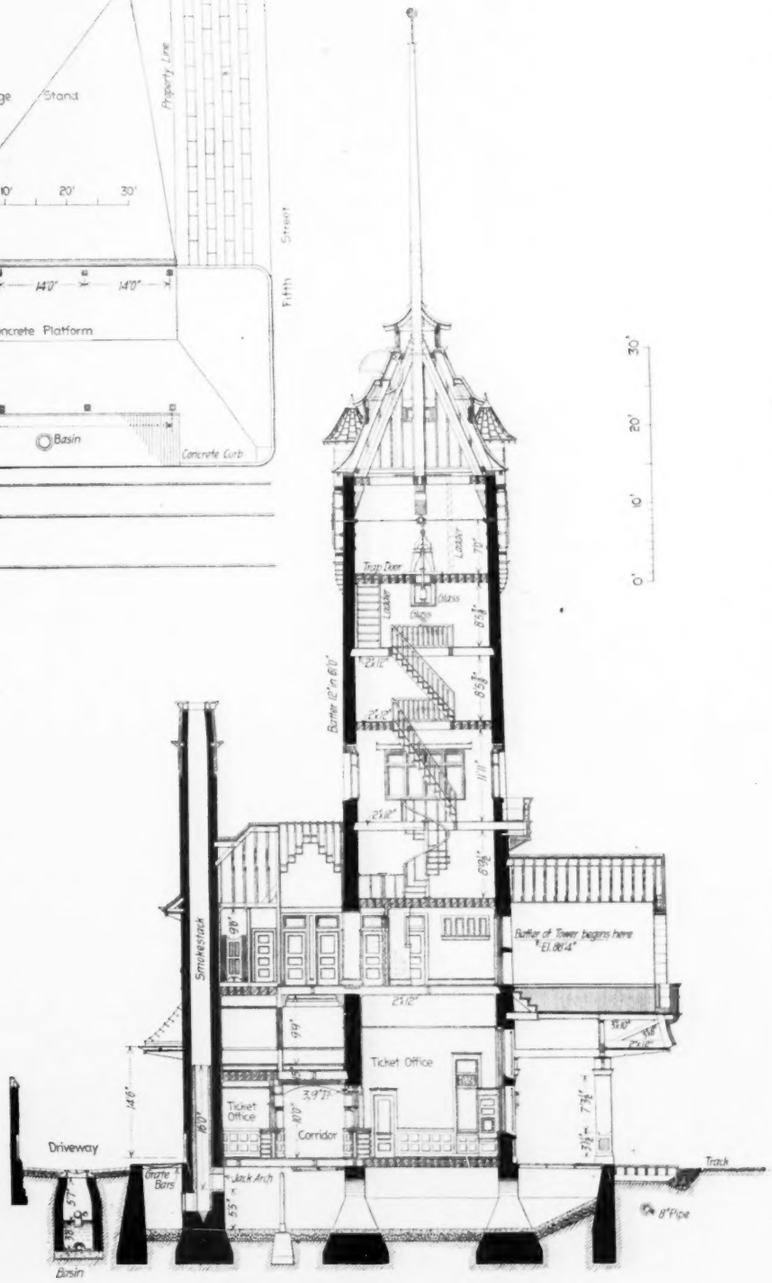


FIG. 3.—CROSS-SECTION A—B THROUGH TOWER.

SENGER STATION AT SPRINGFIELD, ILL.

tect.

Scoullar & Bierwirth, Chicago, Ill., Contractors.

mittee report of the sewer and water commissioners, dated June 14, 1899. The full report is printed in the "Saratogian," for Feb. 13, 1900.

The instructions for longitude and latitude determinations, published in this issue, and for which we are indebted to the courtesy of Mr. William S. Post, late of the U. S. Geological Survey, have been specially compiled for work of this type in rough country, remote from any permanent headquarters and under conditions which require a minimum of equipment. The material has been gathered from a number of sources, and the latest and best authorities and methods have been used. This compilation of data, while prepared for topographical reconnoissance by parties of the U. S. Geological Survey, will be found valuable by anyone engaged in similar work.

RELATIVE FREIGHT RATES ON LARGE AND ON SMALL SHIPMENTS.

There has been much discussion of late concerning the question whether the large shipper or the small shipper ought to bear the burden of any increase in railway freight rates, assuming that such an increase is to be made. Early in the year the railway companies announced a change in freight classifications, the effect of which was to raise the rates of freight on a great variety of merchandise shipments. Various commercial organizations opposed this advance, and argued that if the railways wanted more revenue from freight traffic, they should raise the rates charged for bulk freight and the rates charged to large shippers, or at least that all classes of freight should be advanced equally. They presented forcibly an idea, which is frequently put forward, that the railways actually lose money on the handling of through competitive freight, hauled at low rates in great quantities, and make up their losses by charging higher rates on small shipments.

A similar idea is continually cropping out in different forms. A well-known student of sociological matters recently expressed the opinion that the reduction in average ton-mile freight rates was a delusion. "The rates are as high on merchandise goods as they were twenty years ago," said he, "and the average ton-mile rate has merely been reduced by the great increase in soft coal traffic, carried at very low rates." The New York State Canal Committee, in their recent report, expressed the opinion that the movement of bulk freight by rail at a cost of 2¼ mills per ton-mile or less, is probably done at a loss.

Again there is some tendency, even among railway officers, to look upon the hauling of low-class bulk freights as a field of little profit. No railway company so keeps its accounts that the relative cost of handling different classes of traffic can be accurately known. The auditing department is the only one where even an approximate idea concerning it could be obtained, and on most railways nothing more than routine clerical work is ever expected from the auditing department. It is not strange, therefore, that the financial heads of a company, unfamiliar with the details of practical railway operation, should frequently gain the idea that low rates on traffic always mean small profits, or perhaps no profits at all. This idea has been so often reiterated in the public prints that it has come to be pretty generally believed. We do not now say that it is not true; what we do say is that its truth or falsity ought to be better demonstrated in any case before it is accepted.

The importance of the question of relative rates is well understood. The favorable rates extended by railways to large shippers are declared to be a chief advantage which trusts and consolidations possess over their small competitors. The relation between the car-load and less than car-load rates exerts an important influence in the competition between the larger and the smaller commercial centers. A moderate change in rates may make business in one city stagnate and that in its competitor flourish. We believe, therefore, that some discussion of the question of relative rates and of the reasons why the railways are justified in varying their rates on different classes of traffic may be of interest at this time.

It should be clearly understood at the outset, however, that to fix an absolutely equitable rate—one that shall be as fair to the railway company as to the shipper—is a practical impossibility; and it is equally impossible to define exactly what relation the rates on different classes of traffic should bear to each other. All fixing of railway rates, whether done by a railway corporation or a governmental body, whether for roads owned by private corporations or those owned by a State, must be at best an approximation and a rough one at that. It is no more possible to fix and assess an absolutely equitable charge on every class of traffic than it would be to fix the postage on each letter sent in proportion to the actual cost of its carriage and delivery.

What can be done, however, is to lay down the principles which should govern in the making of rates. Their actual determination must be a matter for good business judgment, guided by these principles.

The first of these principles is that each class of traffic ought to pay a rate to the railway company at least high enough to repay the operating expenses incurred in handling it. Upon the correctness of this principle there is uniform agreement. The most case-hardened defender of the old theory of free competition, and of rate-cutting as a means of getting the best of an adversary, will admit that when less money is received for a shipment than is actually spent by the railway company in handling it, the business had better be refused. As nearly as possible, then, each class of traffic ought to bear the cost incurred in handling it.

Now taking the average of all railways in the United States, about two-thirds of their gross earnings are used up in the payment of operating expenses, and the other third goes to pay taxes, interest on bonds and dividends on stock. If, then, we can estimate for each class of traffic and apportion to it the operating expenses due to its carriage, we shall provide for two-thirds of the necessary railway revenue. It only remains then to consider how the additional amount necessary to provide for the payment of taxes and of income to the owners of the railway bonds and stocks shall be apportioned among the different classes of traffic. At first thought it may seem most just to make this apportionment on the basis of the expense incurred and simply increase by one-third the rates found in the manner above stated. Closer study, however, shows this to be really an arbitrary rather than an equitable basis of adjustment. The real principle which should govern is that each class of traffic, after paying for the expense incurred in handling it, ought to pay for the privilege of using the road in proportion to the benefits received. The value of the goods shipped is a better index of this benefit than is the cost of their carriage; and it is, therefore, by no means inequitable that the valuable high-class merchandise should bear a larger proportion of the "fixed charges burden" than the low grade bulk freights.

According to this, the time-honored principle of charging in proportion to what the traffic will bear is founded on an equitable basis, and its observance by the railway managers is in the public interest as well as in the interest of the railway corporations.

To illustrate this by a concrete case: Let us suppose that a railway is to be built in a gold mining district to have for its sole traffic the carriage to a market of the product of two mines, one a mine producing a very rich ore carrying, say, $100 per ton, and the other a low grade ore carrying only $5 per ton. To simplify matters, let us suppose that the railway is built by the owners of the two mines in partnership, and each furnishes his own rolling stock and hauls his own traffic. Each class of traffic, therefore, will pay all its direct expenses. Before building the line, however, the two partners come together to agree on an equitable basis to proportion the interest on the money borrowed to build the road. The partner with the low grade mine may ship ten times as many tons per annum as the other, but he cannot and ought not to pay ten-elevenths of the cost of the road. To do so, we may suppose, would make his cost of transportation so great as to prevent him from shipping his ore at all. The ore of either mine, we may also suppose, will be valueless without the railway, and neither mine owner can afford to build it alone. It is, therefore, decided that the total value of the ore shipped annually from each mine is a just criterion of the benefit which the railway has bestowed upon each mine owner, and in that proportion it is agreed to divide the cost of the road's construction.

This is, indeed, an extreme case; but it nevertheless fairly illustrates the principle which should control in fixing railway rates. It is not for the interest of shippers of high-class goods that rates on low grade freights should be so raised as to cause the loss of that traffic. The larger the tonnage which a railway carries, the more economically it can handle its business and the less the charge per ton which will have to be made to cover the fixed charges of the company and provide for its dividends.

It will be noted that in the above discussion we have considered only the question of relative rates and have assumed that the net earnings of the companies are to be neither increased or decreased. That is a question by itself and one upon which we will not now enter. Neither have we attempted to defend the practice—happily now far less common than formerly—of rating freight at competitive points far lower than at non-competitive, regardless of its class or the cost of its carriage.

As we have seen above, the actual operating expense cost of moving freight should account for two-thirds of the rate charged upon it. It is chiefly because the cost of moving bulk freights in large shipments over long hauls is generally overestimated, and the cost of handling the small merchandise traffic is generally underestimated that we hear so much complaint of exorbitant railway rates.

We have laid much stress in this journal upon the revolution in rail transportation which has been brought about through the introduction of large locomotives and cars and heavy train loads. We have shown* how, under the most favorable conditions, it is possible to move through bulk freight by rail in great quantities, over long hauls, at a cost as low as one mill per ton-mile. All these conditions must be present, however, to make any such rate even possible, and such a combination is extremely rare. Any departure from it in any particular means a large increase in the cost of transportation.

The great fact which must be comprehended before a correct comprehension of this subject of relative rates is possible, is that in American railway practice the influence of distance has been almost annihilated. Of the total expenditures in the freight department of the railways of the country, taken as a whole, a small proportion is the cost of moving the long through trains over the road on the lines of heavy traffic. The great bulk of the expenses are incurred in loading and making up these trains at one terminal and disposing of them at the other, in collecting from thousands of small stations the many small shipments which are finally united to form the great traffic streams which flow toward the great commercial centers, and, finally, in distributing the opposite streams in a similar manner. If once this state of affairs is clearly understood, it is easy to see how railway companies can make good profits in the movement of through freight at rates which seem little less than suicidal, and to see, too, how such rates are no criterion whatever as to the cost of movement of freight of other classes.

The greatest item of expense on every railway is its pay roll. We may consider the railway company as a manufacturer, and its trains as so many machines for manufacturing transportation. Watch the movement of the long through trains on any road of heavy traffic and see how few men are required to manufacture transportation at the rate of 10,000 or 20,000, or even 40,000 ton-miles per hour. Then watch the process of making up these trains in the terminal yards or at division points. Go out to the local stations and watch the crew of a way freight shifting the cars on the sidings, picking out one here and dropping another there. Remember that on many roads of heavy traffic half as many switching locomotives as freight locomotives are in service. Such studies

*Eng. News, Oct. 26, 1899.

help one to understand the conditions which we are attempting to make clear.

In the concentration of attention on the through freight traffic, it is apt to be forgotten that the bulk of the freight train mileage of the country is made up of the movement of local or way freights. Even on the large roads this is true. Fully-loaded trains on any of these roads carry from 500 to 2,000 tons of paying load; but the average freight train load on any of these roads is a small percentage of this. Further, of the 190,000 miles of railway in the United States, not more than one-third is comprised in the lines of heavy traffic; less than 12,000 miles are double-tracked. On 100,000 miles or more of the country's railways the only freight train is the way freight.

Very few of these trains are fully loaded, nor can they be from the nature of the case, yet the trains must run regularly to accommodate the public, week in and week out, the year round. The train crew for such lightly loaded, slow moving trains is nearly or quite as large as on the long through freights. The locomotive expenses are only a little less. Probably it would be well within bounds to say that the average cost to the railways of the country of collecting car-load freight, and hauling it to division points where it can be made up into full train loads, and of the same process of distribution at the other end of its journey, amounts to 5 to 20 times as much per ton-mile as the cost of hauling the same freight where it can be handled in full train loads over long hauls on railways equipped and managed for the economical movement of such traffic.

If this is true of freight shipped in car-load lots, it is even more true of the "less than car-load" shipments, which in the aggregate constitute a larger proportion of the total freight business. The average load of the cars engaged in moving this class of freight is and must necessarily be far below their capacity. Careless management in this department can bring about gross waste. A story was told in one of the railway clubs a few years ago of a certain freight car which was hauled half-way across the continent, passing over several different railway lines, and when opened at its destination its entire contents was found to be one 50-lb. tub of butter. Many railways now have systems of inspecting and reloading cars handling this class of traffic; but this again costs money.

A large proportion of the freight department's clerical expenses are due to this class of traffic. Nearly the same routine must be gone through for a shipment of a crate of glassware as for a car-load of lumber. The bulk of the station expenses chargeable to freight traffic, too, are incurred in handling the "less than car-load" shipments. The large shippers do business direct with the heads of the traffic department or their immediate lieutenants.

It is probably true that improvements and economies are possible in handling this class of traffic. Comparatively little attention has been paid to it in American railway development, and the progress in the direction of large cars and large locomotives has tended to increase, on the whole, the expense of its handling. We may yet see ten-ton cars built for local service in some parts of the country, when the old light-capacity cars still running have all gone to the scrap heap.

The profits made by the express companies and by the English railway companies, whose traffic is so largely of this character, show that it is possible to make this class of traffic pay well; but it is noticeable that in each of these cases the traffic is subjected to rates considerably higher than those charged by American railways, which sustains our position that this class of traffic is necessarily expensive to handle.

In conclusion, it may be asked what the railways can do to convince the public that their adjustments of relative rates are not inequitable. We can think of no better plan than to undertake to compile and open to public inspection some statement of the relative operating expense cost of moving different classes of traffic. We do not mean by this any hard and fast system of record, involving additional clerical labor and expense; but merely such an apportionment of expense as a competent accountant, familiar with operating details should be able to compile from the records already kept by the company. Such a showing would be a valuable guide to the traffic department in the work of adjusting rates, and would do much to justify the railways' contention that its officers are more competent to equitably adjust rates than any State or National Commission unfamiliar with the details of railway operation can possibly be.

LETTERS TO THE EDITOR.

A New Kind of Wireless Telegraphy.

Sir: I have recently noticed that the Wireless Telegraph Co., of 15 Temple Court, Chicago, is advertising for a "right of way man." They say in their ad: "We propose to start out from Chicago in all directions and want the services of a competent man who understands the business of a right of way man." They also ask for bids for poles.

In my ignorance I had supposed that wireless telegraphy was telegraphy without wires. What, then, do they want of right of way or poles. Or is this same new kind of electric transmission in which the current hops from pole to pole? W. C. F.

Cleveland, O., Feb. 20, 1900.

Skew Connection Details for Roof and Bridge Work—(Correction).

Sir: I desire to call attention to an evident typographical error in the equation at the top of the third column of the article on "The Designing of Skew Connection Details for Roof and Bridge Work," in Engineering News of Feb. 15, 1900. The text reads

$$\frac{h}{(\tan a)} = \frac{h}{(\tan b)},$$

while it should be

$$\left(\frac{h}{\tan a}\right) - \left(\frac{h}{\tan b}\right)$$
$$\overline{\sin B \quad \sin (C - B)}$$

which reduces to, etc. Yours truly, C. A. P. Turner.

Minneapolis, Minn., Feb. 21, 1900.

Repairing Steel Tapes.

Sir: The article on repairing of steel tapes, in your issue of Feb. 22, touches a subject of interest to all users of steel tapes. On account of the difficulty of getting breaks properly repaired I have always attended to mine personally, and used to rivet them somewhat as described in your article. But the necessary reinforcing piece under the break makes the repaired tape stiff at this place and consequently more apt to break at each end of the lap. Soldering has proved much more satisfactory to me, and it can be done by any jeweler or tinner without special tools or devices as follows:

From a strip of thin tin plate, copper or brass, ⅛ to ¼-in. wide, cut a sufficient length to bend once around the tape to be mended and meeting on one side with a butt joint, not a lap. Lay the broken ends of the tape together, pinch the ferule thus made around the break and solder by flowing as little solder as possible under the ferule. If any solder remains on the tape outside of the ferule, scrape it off, as it will make a stiff place in the tape.

When properly done this will leave the tape perfectly strong and capable of withstanding as short a bend as before and leave no sharp edges to catch, and it will also run into any case without trouble. If the break to be mended is not square enough to be covered by this narrow ferule do not be tempted to use a wider one, but insert a piece of old tape one inch or more long and use two ferules.

The writer has never known one of these mends to fail, or the tape to break beside one when properly made. He has just discarded, only because it was otherwise worn out, a 25-ft. pocket tape after 18 years' use, that had six ferules on it. Arthur C. Aldrich.

Newport, Perry Co., Pa., Feb. 24, 1900.

The Barren Island Reduction Works.

Sir: I have read with close attention and great interest the article in your issue of Feb. 1 on "The Barren Island Reduction Works, Greater New York." The magnitude of the enterprise—largely out of proportion to the limit of the contract—appears to be commensurate with the sanitary necessities of the Greater City, and the authorities, both state and local, will have an enormous responsibility thrust upon themselves if the threatened legal steps against these works should end disastrously for them. It is useless as well as childish to enter into or maintain the idea of adopting other methods of disposing of the kitchen offal and animal refuse of cities, small or great, by throwing the stuff into lakes or water courses, or to fool with it by trying to burn American garbage which is altogether different from what is termed "garbage" in England and Canada. It is manifestly an idle task, not so say a criminal one, to trifle in any manner whatever with the garbage disposal problem. The comfort and health of a few persons (possibly prejudiced) are, on general principles, as sacred in the eyes of the law as the comfort and health of a million; but, as a question of public policy, the choice is to be made, in which scale should the weight be thrown? Just so long as garbage disposal is located beyond the limits of cities, long hauls will be a necessity; and the greater the distance, the larger the expense to the community for transportation as well as the discomfort to the population en route.

I emphatically confirm what you say about the necessity of separating kitchen waste from ashes and other refuse, not only making it thereby available for utilization but also saving expense in transporting otherwise mixed stuff. In my opinion garbage works, provided they are properly erected, carefully conducted and fitted up with proper sanitary appliances, can be maintained in or contiguous to a city, with no more nuisance than might be expected from a tobacco factory or a foundry. The St. Louis Sanitary Co., after eight years of experience and great expense for continued improvements, irrespective of profits (which are obliged to give way to sanitary conditions), has arrived at a point where no nuisance is created by its operations, complaints of citizens being confined to the odors of the raw garbage as it is hauled along the streets in carts sometimes carelessly left uncovered by negligent drivers. Walter J. Blakely,

Secretary St. Louis Sanitary Co.

St. Louis, Mo., Feb. 21, 1900.

Regarding Transit Surveys.

Sir: I desire to mildly criticise Mr. Gould in connection with his article on "Transit Work" in Engineering News of Jan. 4. The taking of angles by deflection "left" and "right" has been the bane of my life, and for the last ten years I have never permitted a transitman to do it under any circumstances. Of course, the needle checks, but that takes unnecessary time to allow it to settle, and you must clear away axes, chains, pins, etc., etc., and then take the chance of reading the needle wrong. I have known cases where both needle and deflection were read wrong. The only absolute preventative that I know of is as follows:

Instruct the transitman as follows: Set your plate at zero on the "A" vernier, invariably as you stand at the instrument keep the north end of the compass box from you: turn on your back-sight and unclamp the vernier, and read around to the right to the point ahead: clamp the vernier and take the reading. Suppose the angle thus read should be 186° 40′ (this would mean a deflection of 6° 40′ to the right); then unclamp your spindle, turn again on the back-sight and repeat the angle: this time the vernier should read 373° 20′. If the second angle is double the first, you are right absolutely. Of course, the "limb" should be graduated from 0 to 360, which in my experience is the only way to graduate an instrument.

Another serious objection to reversing the telescope is that you are bound to get all the inaccuracies of the instrument in that way. It is impossible to put the instrument in exact adjustment, as to line of collimation, the telescope will not plunge exactly the same at different points on the plate or spindle. By my method there can be absolutely no error except in the graduation of the plate: and the repeating of the angle eliminates that to the gretest possible extent.

Now, as to platting and calculating the notes: I assume the bearing of the first line from station 0 to say station 10, and by the angles calculate the bearings of all other lines. From this I prepare a table in the ordinary way before I do any platting at all, as follows:

Stations	Course.	Dist.	N.	S.	E.	W.
0 to 10.....	N. 10 E.	1,000	..	..	..	..
10 " 14+30....	N.6—30 W.	430	etc.			

I then calculate the latitude and departures as follows:

10°.....log. cos 10°..... = 9.993361
1,000 ft....log. tan 10°..... = 9.246319
Log. 1,000 = 3.00000

9.993361
3.00000

2.993361 = Lat. 984.80
9.246319

2.239680 = Dep. 173.64

A pencil, a straight-edge and a triangle are all the platting tools required, and you can plat the work as closely with a scale of 1,000 ft. per inch, as you can at 20 ft. to the inch, as by this you locate the end of every course with simply two scalings. If you are running northwest, exact distance north and exact distance west of your starting point are obtained. In this manner of platting you also secure a close check on your calculations, as by simply adding your traverse you locate each point independently of the location of the last point, and then the scaled distance between them must be your measured distance on the ground.

I also call Mr. Gould's attention to the manner of correcting the traverse on closing survey. I had a case of this kind involving valuable property depending upon a government meander line on the Mississippi River. There was no dispute as to the location of the two meander corners—about 1 mile apart, which the government notes were supposed to connect, but which an accurate survey would

not connect. The U. S. court held that the survey must be proportional, which meant that every course and every distance was changed to accurately locate this meander line. For instance, each course with its length formed the hypotheneuse of a right-angled triangle, the base and perpendicular of each one was changed in length proportionally to correspond with the true total distance and from the changed bases and perpendiculars a new course and distance was calculated, making a new meander that would exactly connect the two points. Working out a traverse and calculating the closing course seems to me both crude and inaccurate, and as a matter of fact, the calculation involved in changing is simple and very quickly and easily done with logarithmic tables.

I think Mr. Gould is wrong in suggesting going over the traverse to see which courses and distances are most sensitive, etc. I think this is only permissible when the error is such as to suggest an error of one unit of measurement either 50, 66 or 100 ft., or the length of tape or chain you are using. I have found many an error, when a traverse would not close, by simply making an inspection to see if reducing or increasing by one unit would not substantially close the survey, in some one course.

One word more regarding angle readings. In running preliminary needle lines, I have had the box graduated from 0 to 360 on an open sight compass, and thus largely decreased mistakes in readings, because everything being read from the north end of the needle the transitman had only to keep the north end of the box ahead of him and read the north end of the needle wherever it might be, doing entirely away with the danger of reading north for south or east for west, etc. E. T. Abbott.

Minneapolis, Minn., Jan. 16, 1900.

Sir: Commenting upon Mr. Abbott's criticisms of my paper, I would say that, given an accurate instrument, there is no difficulty in accurately measuring and recording the angles of a survey in any one of several different ways, provided proper care be taken in executing the operations. Mr. Abbott prefers to use the transit instrument as a theodolite and describes one of the methods of procedure which may be employed in connection with the latter instrument. The transit is the outcome of the system of field engineering almost universally practiced in this country, which is based on the measurement of the supplementary angle, commonly known as the "deflection angle." I think it will be long before American engineers and surveyors abandon this simple and convenient method so admirably adapted to quick and easy work and revert to the cumbersome processes of the old theodolite. Should they do so, they will find it more convenient to use the instrument to which these processes belong, rather than to use the transit theodolite fashion. My paper dealt with the transit instrument, used as such, and I think that if Mr. Abbott had read it a little more attentively, he would have found that its object was to show how the trouble he has encountered in checking the angle measurements can be easily and certainly avoided.

I quite agree with Mr. Abbott that the best way to plot a survey is by means of the well-known and time-honored system of total latitudes and departures, particularly as most of the necessary work is done when calculating the traverse. It is indispensably necessary, however, to check a plot made in this manner by scaling the length of each course upon the plot, because otherwise a very serious blunder may easily pass unnoticed.

As to calculating a closing course for a description which, when traversed, does not close, it seems to be the only proper and indeed legal way of treating such a case, unless metes and bounds, and landmarks are called for in the description. We have no right to assume any other bearings and distances than those given for any course but the last one. That one is governed by the clause "To the place of beginning." Consequently, we must get back to the starting point by a course and distance that will take us there, irrespective of that given in the deed. If I do not greatly mistake, in law, distance control bearings, and specified points control both.

I think that what I said about going over a traverse to locate errors, covers what Mr. Abbott states to be his own practice, only I go a little further, and include what should be done after the traverse closes "substantially" but not exactly.

E. Sherman Gould.

Yonkers, N. Y., Feb. 19, 1900.

COST OF COAL OUTPUT in various countries is discussed in the London "Iron and Coal Trades Review," as based upon average annual output per workman, and average value per ton at the mine. As figured upon the first basis, New South Wales comes first, with 455 tons per man per year; the United States is next, with 450 tons; then, New Zealand, 440 tons; Tasmania, 320 tons; Great Britain, 297 tons; Germany, 271 tons; Victoria, 264 tons; France, 216 tons, etc. The value at the pit for the above countries, is $1.34, $1.11, $2.40, $1.92, $1.56, $1.77, $2.20 and $2.00 per ton respectively. British India mines the cheapest coal, at 89 cts. per ton, and has the lowest output per man, or 68 tons per year; this anomaly is due to the low wages paid. Next to India the United States mines the cheapest coal.

NOTES FROM THE ENGINEERING SCHOOLS.

Massachusetts Institute of Technology.—A new course on Heating and Ventilating has been introduced in the Department of Mechanical Engineering. It will be conducted by Prof. S. H. Woodbridge.

New York University.—The Executive Committee has decided to appoint a professor of machine construction, an instructor in machine drafting and a shop superintendent for the School of Applied Science. A number of new testing laboratories have been established in connection with the courses in mechanical and chemical engineering.

Harvard University.—The University will build a mining laboratory. The plans have been prepared and contractors are at work on the estimates, and will begin work in the near future.

A new laboratory has been established for investigating and testing road materials. The three principal tests so far developed are upon the resistance to wear, relative toughness and cementing value of various stones. Fragments about the size of those used on roads are inclosed tightly in a diagonally pivoted iron cylinder, which is rapidly rotated, the motion throwing the stones from one end of the cylinder to the other and subjecting them to both wear and impact. The relative toughness is determined on small fragments of stones by subjecting them to constantly increasing blows from a spherical hammer until they break. The same machine, with special appliances, is used for testing the cementing value of stone. The machine makes a record of the energy and effect of each blow, as well as the final breaking point of the stone.

Columbia University.—It has been decided by the faculty of applied sciences to introduce courses in marine engineering, naval architecture and locomotive engineering. Students following the marine engineering option will take such subjects as marine engine and boiler design, naval architecture, ship-building, marine auxiliaries, appliances and materials and propelling machinery, and practical instruction will be given in the heat and steam engine laboratory. A thesis will be submitted before graduation which will include the design of a vessel and its machinery. The instruction in locomotive engineering is to be given by Prof. Edward L. Coster, who has been recently connected with the Baltimore & Ohio R. R.

University of Michigan.—The following is a list of the theses to be prepared by the senior class in mechanical engineering: "Test of the Fan system of Heating in the Law Building of the University," "Test of the Ypsilanti Power-House of the Detroit, Ypsilanti & Ann Arbor Electric Ry.," "Test of a Dearing Rotary Engine," "Design of a 150-ft. Span Electric Traveling Crane," "Test of the Birmingham Power-House of the Detroit & Pontiac Electric Ry.," "Test of a Gas Engine," "Experimental Determination of the Stresses in Large Fly-Wheels," "The Use of Exhaust Steam from Power Plants for District Heating," "The Design of a Compound Gas Engine," "The Determination of the Flow and Friction in Hot-Water Heating Pipes," "Test of the Power-Plant of the Jackson Light & Power Co.," "Test of Power-House Auxiliaries," "Design of an Air-Compressor, with Liquid-Air Attachment, to Deliver Air at 5,000 lbs. Pressure per sq. in."

In working on the problem of securing a larger supply of electricity from the University power plant for the homœopathic hospital now building and the new science hall soon to be erected, Mr. Carroll D. Jones, of the Department of Electrical Engineering, has obtained the following interesting data showing the operating expenses of the present plant for a year:

Interest, depreciation, etc.	$2,274.00
Labor	1,775.00
Supplies, oil, waste, etc.	251.00
Lamp renewals, carbons and globes	840.00
Coal	450.00
Total	$5,590.00

Only 25% of the coal used is charged to the lighting and power account, as the exhaust steam from the engines is used in the low-pressure steam heating system on the campus. The total amount of work done by the plant at the present time in a period of one year, is 179,700 kilowatt-hours. This gives 3.112 cts. as the cost per kilowatt-hour. At the time the plant was installed the University was paying the Ann Arbor Electric Light & Power Co. 13.39 cts. per kilowatt-hour. From these figures it would appear that the University saves by owning and operating its own plant 10.287 cts. on every kilowatt-hour of electricity used. If the University had to pay for the electricity it is now using at the old price of 13.39 cts. per kilowatt-hour the cost of lighting and power would be $18,470 more than it now is. With 3.112 cts. as the cost per kilowatt-hour the cost of operating a 16-c. p. incandescent lamp per hour is .186 cts. and the cost per hour for the arc lights 1.43 cts. With generators having a normal capacity of 1,500 amperes the cost of electricity can be reduced below 3.112 cts. per kilowatt-hour and .168 cts. per lamp hour. The estimates as worked out by Mr. Jones are as follows:

Interest, depreciation, etc.	$5,187.00
Labor	2,375.00
Supplies, etc.	1,884.00
Coal (25% of coal used)	1,065.00
Total	$10,511.00

The total output of the plant would be 425,000 kilowatt-hours; the cost per kilowatt-hour 2.48 cts.; and the cost per lamp hour .15 cts. The present light and power distribution is by direct currents at 220 volts pressure.

The new homœopathic hospital now building will be supplied with a very complete system of ventilation. Fresh air will be constantly forced into the several wards by fans and fans will be used to draw the foul air into the ventilation stack. It is said that it will be possible to change the air in the entire building within ten minutes.

On Jan. 12 the Universities of Chicago and Michigan debated the question of "The Municipal Ownership and Operation of Street Railways as Compared with Operation by Private Corporations," Michigan won, upholding private control. On April 6 a debate will be held with the University of Minnesota on the subject, "Whether the Economic Advantages of Trusts Are Sufficient to Justify Their Existence Under the Law." Michigan will maintain the affirmative.

The Board of Regents has decided to establish an extensive commercial course next fall. Instruction will be given which will train men for diplomatic and consular duties, for newspaper work, for the higher commercial pursuits and for public administration. There will be courses in commercial geography and statistics. It will necessitate the addition of a professor, an instructor and several assistants to the faculty.

A five-kilowatt universal alternating dynamo is being constructed by the students in the department of electrical engineering. The dynamo is primarily a laboratory machine. It is so designed that one, two or three phase currents can be generated, and in this respect it will do the work of three different kinds of dynamos.

The demand for beet sugar chemists has been sufficient to make it desirable that the beginning course in that subject be repeated in the spring semester. Beets for anaylsis have been freely supplied by the various factories and also by the farmers. The advanced students are making studies of the sugar content of the beet. The juice is expressed under various pressures (as high as 400 atmospheres), and analyses are made both as to sugar content and as to purity. Analyses are also being made of different portions of beets to determine how the samples should be taken from the beet to insure a representative portion.

Western University of Pennsylvania.—The trustees have decided to erect a new astronomical observatory which will be one of the finest in this part of the world. The buildings are to be erected in Riverside Park, Allegheny, Pa., and are to cost $250,000.

Brown University.—Lyon Hall, which the department of civil engineering has occupied for two years, was so greatly damaged by a recent fire that instead of repairing it the corporation will erect on its site a new building.

Cornell University.—The College of Civil Engineering has just manufactured a rotary photographic camera which takes the whole horizon in

a single exposure. This rotary camera will be used in the surveys of the lakes of central New York.

The Sibley College exhibit at Paris this year will consist of a complete line of drawings in machine design, a bound collection of problems in senior work, a bound collection of reports of research work done in the laboratories, three bound volumes of problems in machine design recently solved, a set of blue prints illustrating the shop work, and photographs of exteriors and interiors.

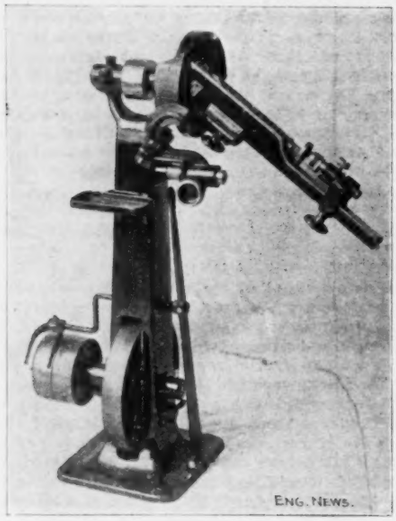


Fig. 1.—The Yankee Drill Grinding Machine.
Fuller Mfg. Co., Kalamazoo, Mich., Makers.

University of Wisconsin.—The Regents have followed the recommendation of President Adams to establish a commercial school. It is estimated that $10,000 a year will be required for such a department, and, if the funds are obtainable from the present resources of the institution, the branch will be organized next fall.

Armour Institute of Technology.—The faculty of the Technical College have adopted the following regulations for the conferring of degrees:

The degree of Bachelor of Science, in the course pursued, is given for the completion of one of the regular engineering courses. For the degree of Mechanical Engineer, Electrical Engineer or Civil Engineer, the graduate may qualify himself in either of the three following ways: (a) Pursue post graduate study for one year at the Institute, and engage for at least two years in successful engineering practice or teaching, of which at least one shall involve responsibility. (b) Submit a thesis after at least three years of successful engineering practice or teaching, of which two shall involve responsibility. (c) The graduate may engage in successful engineering practice for at least four years, of which three shall involve responsibility.

Three new polyphase machines, aggregating 35 HP. and guaranteed to develop at least 70 HP. for a short time during test, have been specially constructed for the Institute and installed in the Electrical Engineering Department. The largest machine is a 15-HP. rotary converter, so designed and constructed that a direct current taken from the laboratory circuit may be converted into either a two-phase or a three-phase current. This machine is also furnished with a pulley by means of which it may be driven mechanically and made to generate either two-phase or three-phase currents or direct current as desired. The second machine is an induction motor, having a rated capacity of 10 HP. and designed to be run by either the two-phase or three-phase currents obtained from the rotary converter. For experimental purposes it may be made to develop at least 20 HP. The third machine is a synchronous motor of the same size and to be run under the same conditions as the induction motor. The 15-HP. rotary converter runs either of these motors to the breakdown point, that is, to where the motors come to rest due to overload, without injury to either of the machines. The combination of two-phase and three-phase in these three machines allows them to serve the purpose of six machines such as are used in practice and at the same time the cost and space occupied is reduced nearly 50%.

DRILL GRINDING MACHINE WITH SINGLE ADJUSTMENT.

The drill grinder is an important item in the equipment of modern machine shops, where tools are ground for the men, instead of each man employing part of his time in grinding his own tools. In most of these drill grinding machines a number of operations are required in order to adjust the machine for grinding any particular size of drill. In the new machine, which is illustrated herewith, the mechanism and operation have been greatly simplified, with the important result of obtaining a much greater capacity of output. In brief, the machine is so designed that no special adjustment is required on account of the variations in the diameter of the drills, the size of the drill to be ground determining its proper position in the holder; thus, a ½-in. drill always stops at a certain place, and cannot occupy the position intended for a ¾-in. drill. Another special feature of the machine is an adjustable clearance device, which gives the same amount of clearance for every size of drill within the range of the machine (⅛ to 2¼ ins.) without any resetting of the different sizes. If the drills are all used in the same material (that is, for drilling iron, brass, etc.), the machine is set once for all at the desired clearance, and the ratio then holds good for every size of drill. If some of the drills are used for iron, others for brass, wood, etc., the proper clearance suitable for the different drills can be given by means of a rapid adjusting device.

A general view of the machine is shown in Fig. 1, while Fig. 2 shows the details of the mechanism. In Fig. 2, (A) is the main frame of the machine, with a soft emery grinding wheel (B), which is driven by means of a pulley (C) or by an electric motor mounted in place of the pulley. On the main frame is a bracket (D) with a cylindrical arm (E). On this rides the sleeve (F) which is at right angles to the plane of the face of the grinding wheel. This sleeve has an arm (G) extending behind the line of the wheel, and having at its end an inclined journal bearing (H), which is adjustable by means of the clamp screw (I) on the open side of the bearing. It is fitted moderately tight to the journal, so that some pressure will be required to rock the latter in the bearing.

Into this bearing is fitted the turned end of the curved arm (K), the axis of the journal being at an acute angle with the face of the grinding wheel. The outer end of this arm is formed as a loop to pass around the edge of the wheel, and the outer end at (L) is formed into a seat for the drill holder (M), the underside of which is rounded so as to be adjustable in the seat. The screw (N), operated by a hand-wheel, extends up through a slot in the seat (L) for the purpose of adjustment. The underside of the seat is formed on a curve to correspond with the curved fit of the drill holder in the seat, so that the drill holder can be rocked in its seat. The curve on which it is rocked is an arc of a circle struck from the apex of the V-shaped longitudinal groove in the drill holder (M). The adjustment is regulated by a knurled-head worm-gear screw (O) engaging with a rack on the underside of the drillholder. A pointer on the holder moving over a graduated scale on the seat or bracket indicates the adjustment. At the tail end of the drill (M) is an adjustable tail block (P).

The apex of the V-shaped groove at the front end of the drill holder is in line with the axis of the journal (H), so that when the holder swings from side to side it turns on this point as on a pivot. The left-hand side of the front end of the holder is cut at an angle on a line nearly parallel with the face of the grinding wheel. To this is secured a lip rest (Q) adjustable by a screw. The lower portion of the rest is curved slightly outward, to compensate for the difference in the angle of the grooves in the large and small drills. The right-hand side of the drill holder (M) is cut away to permit the holder to swing in grinding the drill without coming in contact wth the face of the wheel. The lip rest (Q), for the drill, is adjustable as such an angle that the front edge of the cutting lip of the drill at its periphery will be in advance of the front edge of the cutting lip near the center of the drill, and this peripheral portion will be ground at a lesser angle of clearance than the portion nearer the center. This is the most efficient form of drill, as the center portion is enabled to cut or advance into the metal at each revolution as freely as the periphery, thus relieving the drill of strain and giving a clear and true cut.

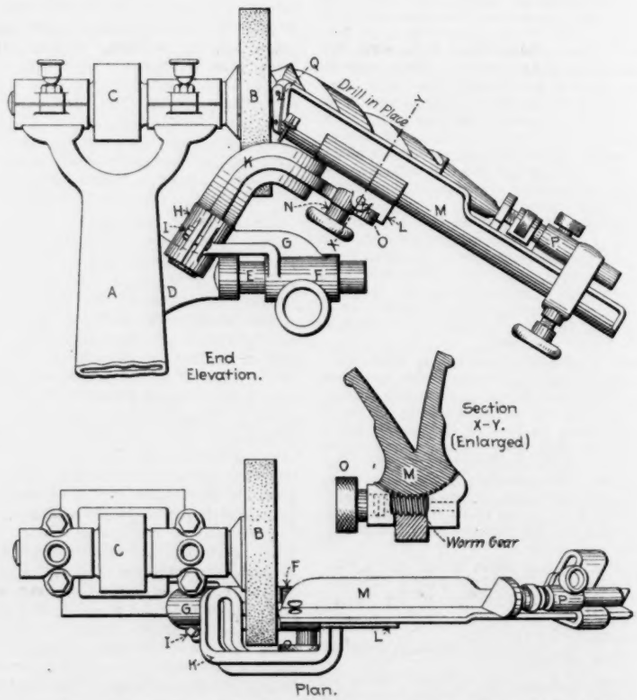


FIG. 2.—DETAILS OF THE YANKEE DRILL GRINDING MACHINE.

As the face of the grinding wheel (B) and the axis of the journal of the drill holder are at an angle to one another, any parts supported in the drill holder and rocked in front of the wheel will be ground to a conical surface. A large drill will not fit low in the angle of the holder, and will be ground to a curve corresponding to the surface of the cone near the base. A smaller drill will come nearer to the apex of the cone, and will therefore be ground to conform to that portion of

the cone. Thus any size of drill placed in the holder is automatically set in the proper position to secure the correct curvature. The only adjustment required is to bring the tail block (P) into contact with the end of the shank of the drill, which is easily and quickly effected.

This interesting machine is termed the "Yankee" drill grinder, and is manufactured by the Fuller Mfg. Co., of Kalamazoo, Mich. The makers state that the machine, which has only recently been put on the market, is attracting considerable attention, and we are indebted to them for drawings and other information used in the preparation of this article.

PLATE GIRDER BRIDGES ON TRACK ELEVATION WORK.

In the article on "Track Elevation in Chicago," in our issue of Feb. 22, reference was made to the construction of the plate girder bridges with solid floors on the joint track elevation work of the Chicago, Rock Island & Pacific Ry., and the Lake Shore & Michigan Southern Ry. In mentioning the contractors for the steel bridge work the name of the Chicago Bridge & Iron Co. was accidentally omitted, although as a matter of fact this company did a considerable proportion of the work. Some further particulars are given below of the plate girder bridges spanning 66-ft. streets, without intermediate columns on the curb line, these particulars being taken from a description prepared by Mr. L. H. Clarke, when Engineer of Track Elevation of this work.

The five girders making up a four-track bridge are alike in sectional areas and details, so that additional tracks can be provided without reinforcement or change. They rest at each end on a 1-in. wall plate anchored to the masonry. The webs of the girders are ½-in. thick, reinforced at the top and bottom chords to 1¼ ins. The top chord is made up of angles 5⁄8 × 6 ins., and cover plates 5⁄8 × 16 ins. The bottom chord is made up in a similar way, but the first cover-plate is 21 ins. wide, so that a riveted connection can be obtained with the lower flanges of the floor-beam hanger plates, for the purpose of side stiffness. The upper corners of the girders are rounded, and the top chord angles are spliced at the tangent points. The first cover-plate is spliced at each end by the second, but all other chord members, and the entire lower chord, is without splice. The girders, when erected, have 3⁄8-in. camber in the floor.

The floor is made up of 10-in., 33-lb. I-beams, 62 for each track, cut at the ends to an angle of about 60°, with hanger plates 7-16 × 9¼ ins., riveted to each end in the shop by means of angle lugs riveted to the webs. These floor beams are riveted to the girders in the field with five rivets connecting each hanger to the web, and with two rivets to the 21-in. chord cover-plate for side stiffness. A continuous sheet of 5-16-in. steel plates is placed upon the floor beams and riveted to them. It is also riveted to the sides of the girders with a continuous seam through the angle irons provided, and is spliced, at the joints with lap plates 3⁄8 × 5 ins. placed below the surface.

The drainage is from the center of the girder span to the ends due to the camber, and at each end the steel sheet covering is finished up with an angle iron, and provided with a gutter of 1⁄8-in. sheet steel, which drains into a groove cut into the coping of the masonry, and from there into the roadbed. Upon the plate covering of the floor, and riveted to it and the floor beams are laid the rail plates and guard rails. The rail plates are alternately arranged for rail fastenings, and for rail-bearings only.

The material is soft steel, excepting the clip washers, which are of cast steel. All workmanship is in accordance with the L. S. & M. S. Ry. specifications. The painting is in three coats. The first, given in the shop and while the material was clean and free from dirt and scale, was a thorough covering with refined linseed oil, which was required to dry on hard. All surfaces which covered each other in assembling were each painted before assembling with a heavy coat of red lead and refined linseed oil. After erection, the bridges were painted with two coats of heavy paint of specified quality and color.

Our attention has been called to the fact that the bridge work on this joint elevation included a bridge at 43d St. of about 70 ft. in length and 249 ft. 6 ins. in width with 19 tracks. The tracks are 13 ft., c. to c., except the main tracks, which are a little further apart. This is all one continuous structure in width, and is of the plate girder and solid floor construction already described. Before erecting the structure, the advisability of making it in section or providing some means for expansion in the direction of its width was considered, but it was eventually decided to build it all solid and let the expansion take care of itself. No appreciable effect upon the alinement of the tracks and no disturbance of the masonry has resulted from this.

AN AMERICAN ARCHITECTURAL ENGINEERING EXHIBIT AT THE PARIS EXPOSITION.

Among the American exhibits at the Paris Exposition will be one, illustrating American practice in architectural engineering, that for effectiveness and completeness has probably never been equaled. Commissioner Peck proposed such an exhibit, and invited the several American engineering societies to unite in gathering together the material; but the Western Society of Engineers was the only one that took up the matter seriously and appointed a committee, of which Mr. Ralph Mojeski was chairman, to consult as to ways and means of carrying out the project. This committee decided to prepare and send to Paris a very handsome model of the Chicago drainage canal, with maps and plans, and this exhibit is ready for shipment. Mr. Mojeski, however, requested Mr. Corydon T. Purdy, M. Am. Soc. C. E., of the firm of Purdy & Henderson, New York and Chicago, to devise means of preparing an architectural engineering exhibit. As an exhibit of the kind proposed would cost a considerable amount and a large amount of time would be required for its preparation, Mr. Purdy went earnestly to work, and first consulted with Commissioner Peck; and this gentleman at once offered to transport any such exhibit to Paris, to erect and maintain it during the Exposition and to take it down and reship it to the United States. Mr. Purdy himself was commissioned as an Honorary Expert for the purpose of facilitating his efforts in this country.

With this beginning made, the George A. Fuller Co., builders and contractors, was next interested in the project, and this firm practically pledged itself to finance the exhibit, with such assistance as it might receive from others interested. The structure selected as a recent and typical American building was the Broadway Chambers Office Building, at Broadway and Chambers St., New York, erected by the George A. Fuller Co., from the plans of Cass Gilbert, architect, of New York and St. Paul, with Purdy & Henderson as consulting engineers. This building is 100 ft. long by 50 ft. wide, and is 17 stories high above the sidewalk, with a basement and sub-basement. It is owned by the Walker Estate, of Boston.

The exhibits, now practically ready for shipment to Paris, may be described as follows: No. 1 is a plaster of paris model of the building, on a scale of ½-in. to 1 ft., showing the exterior of the building, with all its details faithfully reproduced. This exhibit was constructed under the direct supervision, and at the expense of the architect, Mr. Cass Gilbert. Exhibit No. 2, on the same scale, is a model in brass, silver-plated, of the complete steel frame of the building, true to every detail, down to the steel grillage in the foundation resting upon the soil. This foundation work is uncovered so that its construction and the duty performed can be readily understood. The model is intended to reproduce in every detail the countless members making up the steel frame of a modern American office building; and it is an exact reproduction to scale in everything, except, that, instead of being rivetted together, the various abutting members are soldered. As these two models, Nos. 1 and 2, are each about 10 ft. high, they are made in sections for purposes of shipment and erection.

Some idea of the intricate construction of this remarkable model can be had when it is realized that about 1,000 separate pieces of metal are used in each floor of this 17-story structure, with the perfect form of each member retained. Besides the skeleton frame, this model shows the complete elevator plant in miniature, with one elevator in constant operation; exhibits the heating system, to scale, and the piping connected with the plumbing.

Exhibit No. 3 is a full-size section of a corner of one of the rooms in this building, about 10 ft. by 4 ft. on plan, showing the exact construction of the building, with its walls, floor and ceiling. Other exhibits are duplicates of the dynamo and engine used in the actual building, and these are to be in operation; the switchboard connected with the electric generator; full-sized details of the electric wiring; a sample wash-bowl and closet, with marble floor and sides to the room; and models of the steam boilers employed. Exhibits No. 11 to No. 15, inclusive, show full-sized spandrel sections of the building, reproducing in every detail the materials and construction actually used; then come full-size sections of the steel posts with all the floor connections, etc. Other exhibits show a section of a post, with the fireproofing in place and piping disposed about it; the hardware employed, and handsome detail drawings and photographs of this and other large buildings in the United States.

Another exhibit of especial interest is an exhibit of the terra-cotta construction intended to illustrate, in a most graphic manner, the difference in the use of this material in the United States and in France. In the latter country terra-cotta, when used at all, is confined to ornamental details in lighter members; and when mass is desired, stone alone is employed. In the construction here shown terra-cotta is used in masses, as well as in purely ornamental details; and in the two piers and included window to be sent to Paris, the terra-cotta alone weighs about 20 tons. This terra-cotta is again shown in the spandrel sections before referred to. These sections are slices taken down the center line of a window, for example, and including a floor and the top of the window below. To better exhibit them, these sections are laid on the flat and built into a wall, with a projection of about 8 ins., in such manner as to plainly show the section of the wall and all its materials in place.

The description of this most effective and creditable exhibit of American practice in engineering architecture would be incomplete without some reference to the men who originated it and contributed to it. This list is given as follows: George A. Fuller Co., general builders and contractors; Cass Gilbert, architect; Purdy & Henderson, consulting engineers; Carnegie Steel Co., makers of steel work; John Pierce, builder; The Wells & Newton Co., heating plant; Otis Elevator Co., elevators; Perth Amboy Terra Cotta Co., terra-cotta work; Clonbrook Steam Boiler Co., boilers; Brooklyn Electric Equipment Co., switchboard exhibit; Thomas J. Byrne, plumbing; Pittsburg Terra-Cotta Co., fireproofing; Henry Taylor Lumber Co.; Bullock Electric Manufacturing Co., dynamo; Payne Engineering Co., engine; Empire City Marble Co., marble trimmings; Bradley & Currier Co., sashes and doors; Hecla Iron Works, structural details; Russell & Erwin Manufacturing Co., hardware exhibit; The Kenney Co., flushing water closets, without tanks; A. J. Ellis & Co., cornice work.

It might also be mentioned that in preparing these exhibits $13,000 was expended, exclusive of all cost of transportation, erection and maintenance, these latter items being met by the U. S. Government.

A VARIABLE-SPEED POWER TRANSMISSION APPARATUS.

A variable-speed device which allows of a variation of speed by small or large increments as desired, within a wide range of variation, and which is operated instantaneously and without trouble, has an extensive field for its introduction, as for instance on machine tools, conveyors, printing presses, rotary kilns, canning machinery, etc. The Reeves device of this class has been applied to these and other purposes, and its mechanism is shown in the accompanying illustrations. It consists essentially of two shafts mounted in bearings in side frames and having two pairs of conical pulleys, one pair on the driving shaft and the

other pair on the countershaft of the apparatus. These pulleys are capable of being moved laterally on the shaft, and are so connected that as one pair of cones is separated the other pair is brought closer together. The power is transmitted from one shaft to the other by a thick stiff belt whose edges are beveled to fit the slope of the cones. As the cones on the countershaft are separated, the belt slips down to a smaller running diameter, and thus speeds up the shaft, while when the cones are brought together the belt runs on a larger diameter, and the speed is therefore reduced.

Fig. 1 is a plan of the complete apparatus, in which (A) is the driving shaft and (B) is the

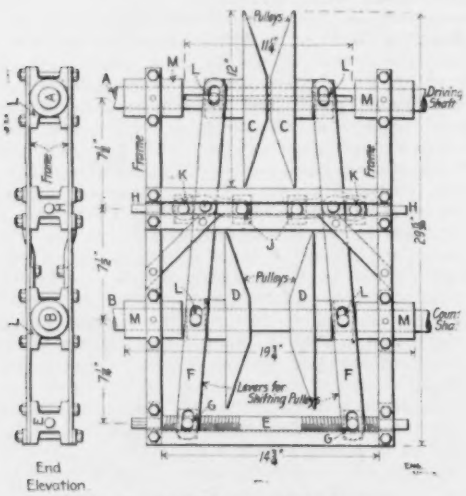


Fig. 1.—Variable-Speed Mechanism. Reeves Pulley Co., Builders.

countershaft, these shafts being journaled in a pair of side frames built up of steel bars. On the shafts are two pairs of cast-iron cone pulleys (C) (C) and (D) (D), which are splined to the shafts and can traverse laterally upon them. At one end of the frame is the steel screw (E), with right and left-hand threads, which operates the cone pulleys by means of two levers (F) (F), the inner ends of which are fitted with cast-iron screw nuts (G) which have brass linings. Between the two shafts is the steel screw (H) for adjusting the position of the levers so as to regulate the tension on the driving-belt. An arm on the lever is fitted to the block (J), and a yoke and pin connect the lever to the cast-iron screw nut (K). The levers operate the cones by means of the thrust blocks (L), and the shafts are carried in long bearings (M).

The belt is of special construction, as already noted, since it drives by the friction of its edges and not of its face. To an endless rawhide belt are riveted cross bars formed of strips of leather with

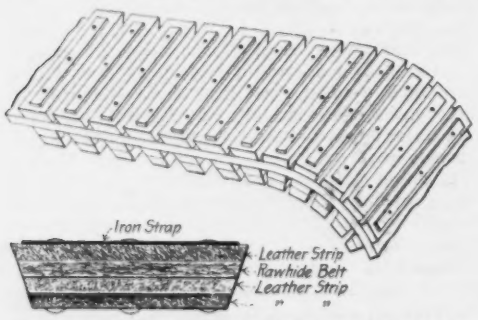


Fig. 2.—Belt for Reeves Variable-Speed Mechanism.

top straps of iron. The ends of these bars are beveled to fit the cones, and the sides are beveled so as to allow them to clear each other in passing around the pulleys. The belt is shown in Fig. 2.

This device is manufactured by the Reeves Pulley Co., of Columbus, Ind., and we are indebted to the makers for blue prints and other information. It has been applied to iron and wood-working lathes, planers and other machine tools, to coal conveyors, rotary cement kilns, canning machinery, and to variable speed machinery driven by constant-speed electric motors. Fig. 3 shows the device applied to the kilns of the Castalia Portland Cement Co., Castalia, O. It has also been applied to motor carriages and to the Vimotum Hydrocarbon Car Co.'s experimental cars for railway service. The machine is built in various

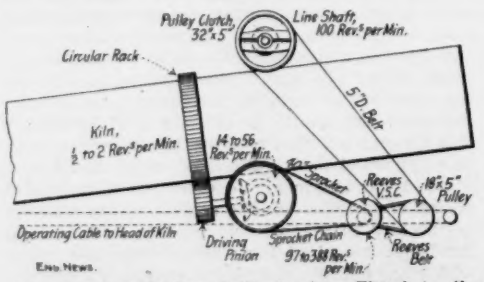


Fig. 3.—Variable-Speed Mechanism Fitted to the Cement Kilns of the Castalia Portland Cement Co.

sizes for transmitting 3 to 16 HP., and with speed variations of 1 to 10 to 1 to 4. The cones vary from 10 to 30 ins. in diameter.

RECENT EXAMPLES OF LOW FREIGHT RATES IN RAIL TRANSPORTATION.

The February letter of the "Anthracite Coal Operators' Association" discusses at length the proposed Delaware Valley & Kingston R. R., and the application now pending before the New York State Railroad Commission for that body's approval of the enterprise. In support of the contention that the freight charges on anthracite coal of the existing railway lines are exorbitant and unjust, the "Letter" presents the following comparison of rates on soft coal and on anthracite:

That the present freight charges on anthracite coal are unreasonably high can be clearly shown by comparison with the rates on soft coal. Both of these varieties of fuel are loaded and unloaded by gravity; a full train load is as easily and cheaply assembled in one case as in another, and there is undoubtedly no greater cost in the actual transportation of a car of either kind. The difference in the comparative rates, and also the rate on grain, a far more valuable and perishable product (previously given in the "Letter") is as follows:

	Value* per net ton.	Miles trans-ported.	Total frght.	Rate per ton per mile.	From	To
Grain	$28.00	912	$3.40	3 7/10	Chicago	New York.
Coal: Soft.	.75	418	.92	2 2/10	Kanawa	Newport N.
Anthr'cite	2.00	800	3.12	3 9/10	Scranton	Chicago
Anthr'cite	2.00	145	1.47	10 1/10	Scranton	Hoboken.
Soft	.75	967	2.30	2 4/10	Gauley	St. Paul.

*Value at shipping point.

These were the rates charged in the summer of 1899. Recently the rate from Scranton to Chicago has been advanced to $4 per ton, or an average of 5 mills per ton per mile, while that from Gauley, W. Va., to St. Paul is $2.65, or 2 7/10 mills per ton per mile.

In the spring of 1898 the Pennsylvania R. R. transported soft coal 267 miles, from South Fork, for 60 cents, at 2 3/10 mills per ton per mile; from Grampton, 274 miles, at 2 2/10 mills. To meet this competition the Philadelphia & Reading R. R. Co. hauled bituminous coal from Patton and other points to Philadelphia, 349 miles, of which 150 miles was over the Beech Creek R. R., at a rate that averaged 1 7/10 mills per ton per mile.

In 1897 the Philadelphia & Reading tariff rates on anthracite were as follows:

		Prepared sizes		Pea.		Buckwheat.	
Schuylkill Haven to	Miles.	Rate.	Per ton-mile, mills.	Rate.	Per ton-mile, mills.	Rate.	Per ton-mile, mills.
Reading	31	$1.40	45 1/10	$1.25	40 2/10	$1.25	40 3/10
Pottstown	53	1.55	29 3/10	1.40	26 4/10	1.25	23 6/10
Phoenixville	65½	1.60	24 4/10	1.40	21 3/10	1.25	19
Marion	74	1.70	22 8/10	1.40	18 6/10	1.25	16 8/10
Philadelphia	89 7/10	1.70	18 9/10	1.40	15 6/10	1.25	13 9/10

Average freight rate in mills per ton-mile. | Average rates on anthracite coal.

	Chesapeake & Ohio	Norfolk & Western.	Baltimore & Ohio	N. Y. C. & H. R.	Beech Cr'k R. R.	Gt. N'thern.	Illinois Central.	Cent. R. R. of N. J., mdse.	All freight. Del., Lack. & W'st.‡	All freight. L. Val.; ex. anthra; Erie R. R.	All freight. cite.	All freight. N. Y. O. & W.	All freight. Average.*	Tide average.	Freight— %.	Freight— Rate.	Rate mills per ton-mile.
1890	5.4	5.71	4.8	7.6	5.2	12.8	9.3	1.16	.....	0.63	0.70	1.27	7.9	3.42	0.45	$1.539	9.2
1891	5.2	5.48	5.1	7.4	5.0	12.4	9.3	1.14	.....	0.58	0.70	1.03	7.8	3.53	.45	1.538	9.5
1892	5.2	5.37	5.4	7.0	4.5	12.3	9.08	1.16	.....	0.61	0.60	0.94	7.6	3.68	.40	1.472	8.8
1893	5.1	5.14	5.6	7.1	4.8	12.3	8.45	1.10	.....	0.63	0.65	0.96	7.7	4.10	.40	1.640	9.8
1894	4.8	4.51	5.7	7.4	4.2	11.0	8.39	1.14	0.931	0.59	0.59	0.91	7.4	3.40	.40	1.360	8.1
1895	4.2	4.66	5.6	7.3	3.8	10.1	8.08	1.10	0.931	0.59	0.53	0.84	7.1	2.99	.40	1,196	7.1
1896	4.3	4.47	5.1	6.7	3.8	10.2	7.45	1.03	0.919	0.56	0.48	0.83	6.8	3.53	.40	1.412	8.4
1897	4.2	4.41	4.6	6.8	3.5	10.4	6.71	0.99	0.921	0.60	0.48	0.87	5.8	3.71	.40	1.484	8.8
1898	3.7	4.04	4.2	6.1	2.8	9.9	6.95	0.91	0.872	0.56	0.41	0.87	6.1	3.58	.40	1,432	8.5
Decline, %, '90-98.	31.4	29.2	12.5	19.7	46.1	22.6	26.8	21.5	16.9	11.1	41.4	31.5	22.7	....	...	.....	7.3

*Average of all roads in N. Y., N. J., Pa., Del. and Md. ‡1889, 1.05.

The comparison between a haul of 349 miles for 60 cents per ton, and 89 cents for $1.70 per ton is ample proof that the latter rate is excessive. At this time the freight on buckwheat coal, $1.25, was the same as the f. o. b. selling price of bituminous coal in Philadelphia.

As a further comparison, the following are the rates at that time charged by the Delaware, Lackawanna & Western R. R. for hauling anthracite coal:

		Miles.	Rate.	Per ton-mile. mills.
Pittston to	Binghamton, N. Y.	71	$1.65	23 2/10
	Elmira, "	128	1.75	13 8/10
	Corning, "	144	1.95	13 5/10
	Syracuse, "	150	2.05	13 6/10
	Oswego, "	185	2.10	11 3/10
	Buffalo, "	274	2.25	8 2/10
	Morristown, N. J.	124	1.55	12 8/10
	Paterson, "	139	1.60	11 5/10
	Orange, "	142	1.60	11 3/10
	Newark, "	146	1.60	10 9/10
	Hoboken, "	154	1.60	10 4/10

In the spring of 1899, bituminous coal transported from West Virginia was delivered at tidewater, New York, for $2 per ton. Deducting 65 cts. at the mines, and 10 cts. for commission and selling charges, leaves $1.25 for freight. The comparison with anthracite is as follows:

	Miles.	Freight.	Per ton-mile.	Selling price.
Bituminous coal	500	$1.25	2½ mills.	$2.00
Anthracite (buckwh't)	154	1.60	10 3/10 "	1.80
Anthracite (stove)	154	1.60	10 3/10 "	3.70

A further comparison is given in the accompanying table showing the average freight rates on various railways and the percentage decrease, as compared with the rates charged against anthracite. It will be seen that while the average freight rates on all classes of merchandise carried on all the railways of the Middle States declined 22.7% in 9 years, the average anthracite rate was reduced but 7.3%.

AMERICAN LOCOMOTIVES FOR THE SOUTH AFRICAN REPUBLIC.

Some mogul tank engines for the new Dundee & Vryheid Ry., in the South African Republic (or the Transvaal) were ordered in the United States several months ago by the government railway department. They were built by the Dickson Mfg. Co., of Scranton, Pa., and are now held at the works awaiting the close of the war. A view of one of the engines is shown in the accompanying cut, and it may be noted that this line, like most of the railways in South Africa, has a gage of 3 ft. 6 ins.

The driving wheels have 38-in. cast-iron centers and steel tires, all the tires being flanged, but those on the middle wheels are 5⅛ ins. wide, while the others are 5 ins. wide. The truck is of the center-bearing, swing-center type. Bar frames of the American type are used. The cylinders are outside, with 2½-in. piston rods, and have steel guide bars, with case-hardened surfaces. The crosshead is of cast steel, and has bronze bearings for the guides, babbitted on the face and tinned on the sides. The connecting and side rods are of hammered iron, and are all of I-section.

The boiler is of the straight-top type, with steel firebox of flanged annealed plates, and short extension smokebox fitted with netting and deflector plates. The crown sheet is supported by radial stays, with nuts on the six central rows. The mud ring is single-riveted, and has the inside and outside corners machined so as to avoid the scarfing of sheets at the joint. The staybolts are turned down to the diameter of the bottom of the thread between the firebox and shell plates. The tubes are of iron, with copper ferules at both ends. The fuel to be used is bituminous coal.

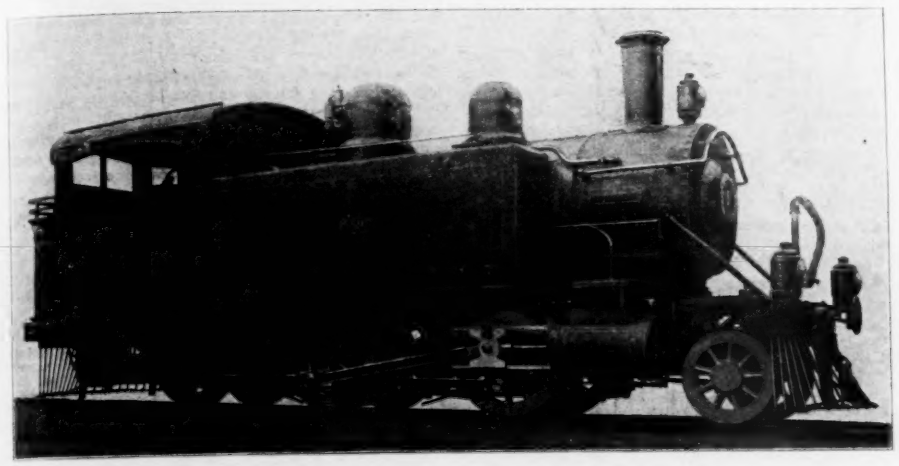
The tanks extend from the cab to the smokebox, and are built of steel, the outside plate ⅛-in. thick, and all others 3-16-in. They are built with rounded corners. The coal bunker is behind the cab, and the sandbox is on the boiler barrel. The en-

gines are fitted with iron pilots and central combination couplers and buffers of a type very generally used for link and chain couplings on the rolling stock of narrow gage colonial railways. The three marker lamps have red and green lenses.

The general dimensions of these engines are as follows, given in our standard form:

Mogul Tank Locomotive; South African Republic.

Driving wheels (6)	3 ft. 8 ins.
Truck wheels (2)	2 " 6 "
Driving wheel centers	Cast iron.
Truck wheels	Cast iron spoke centers; steel tires.
Journals, driving axles	6½ x 8 ins.
Wheelbase, driving	12 ft. 6 "
Wheelbase, total	19 ft.
Weight on driving wheels	68,450 lbs.
Weight, total	78,600 "
Cylinders	14 x 20 ins.
Crosshead	Alligator; guides. Two-bar.
Side rods	Solid ends.
Slide valves	Balanced.
Boiler	Straight top; diameter. 4 ft.
Dome, diameter	2 "
Boiler plates	7-16-in. and ½-in.



MOGUL TANK LOCOMOTIVE FOR THE DUNDEE & VRYHEID RY.; SOUTH AFRICAN REPUBLIC.
Dickson Mfg. Co., Builders.

Horizontal seams (double welt strips)	Sextuple riveted.
Injectors (2)	Hancock non-automatic.
Working steam pressure	180 lbs.
Firebox	Radial stayed; length. 6 ft.; width. 2⅛ ft.
Side, back, crown plates, ⅜-in.; tube plates	½-in.
Crown stays (radial), diameter at ends	1⅛ ins.
Grates	Rocking.
Staybolts, diameter. 1 in.; pitch	4¼ ins.
Water spaces, width, front and back, 3 ins.; sides, 2½	"
Grate area	15 sq. ft.
Tubes	Iron; No. 186; thickness. No. 13 W.G.
Length over tube plates	9 ft. 6½ ins.
Capacity of tanks	1,000 galls.
Capacity of coal space	3,300 lbs.
Brake fittings	Autom. vacuum, connected to hand brake

NEW UNION PASSENGER STATION AT SPRINGFIELD, ILL.; ILLINOIS CENTRAL R.R.

(With two-page plate.)

A union passenger station has recently been completed by the Illinois Central R. R. at Springfield, Ill., and will be used by that road, the Baltimore & Ohio Southwestern Ry. and some other lines. The railway tracks run along Madison St., on the street level, and the station is on the south side of the street, the front platform being a continuation of the sidewalk. The station extends from Fifth St. to Sixth St., a distance of 322 ft. There are three tracks in front of the station (not fenced off from the street), the nearest being a siding from the main tracks. These tracks will be 13 ft. c. to c., with a space of 14 ft. from the street line to the center of the nearest track. A paving of longitudinal planks is laid between the rails and tracks, while a platform 8 ft. 6 ins. wide of planks laid tranversely to the tracks, extends from this paving to the main concrete platform, for the reason that the planks are found to be less slippery than the concrete in damp or wet weather. There is no trainshed, but a roof extends over the whole length of the concrete platform, 332 ft., supported by columns along its edge. In the rear of the building is a driveway 14 ft. wide, with two porte-cocheres, or covered entrances opening into the two main waiting rooms. The driveway is shut in by a brick wall and can be closed by ornamental iron gates at the entrances at Fifth St. and Sixth St. At the east end of the building is a square space for a wagon stand, and at the west end is a similar space for a carriage stand.

Fig. 1 is a general plan at the level of the first floor. Fig. 2 is a section (looking east) through the women's waiting room, showing the platforms and driveway, and showing also the entrance gates in elevation. Fig. 3 is a cross section (looking west), through the center of the building and tower. Fig. 4 is a general view of the track side of the station, fronting on Madison St., reproduced from a photograph.

The station building is 210 ft. long and 34 to 43 ft. wide, with a height of 14 ft. 6 ins. from the floor level of the waiting room to the eaves, and 41 ft. 6 ins. to the roof cresting. In the middle is a square clock tower, 89 ft. high from the platform to the eaves, where it is 20 ft. square, the sides having a batter of 12 ins. in 61 ft. The building is of brick, terra cotta and stone, and the general treatment is in the style of the Spanish renaissance. The lower portion of the walls from the stone water table to the continuous 10-in. course of buff Bedford limestone level with the window sills, is of dark brown brick; above this, to a height of 6 ft., red brick is used, topped with a 15-in. string course of Bedford stone. Above this stone course the walls are of buff brick, the same brick being used also for the tower. The terra cotta trimmings are buff and red in color, and the roofs of the building, tower and platform shelter are of red tile.

The center portion of the building has two ticket offices, 17 ft. 6 ins. × 17 ft. 6 ins. and 21 ft. × 10 ft. 9 ins., one on each side of a corridor 8 ft. wide, this corridor having arched entrances to the waiting rooms at each end. On the left of this center portion is the women's waiting room 53 ft. 8 ins. × 24 ft. 10 ins., with a toilet room 8 ft. 7 ins. × 8 ft. 10 ins., and beyond this again is the baggage room, 27 ft. 2 ins. × 31 ft. 2 ins. On the right of the center portion is the men's waiting room, 53 ft. 8 ins. × 24 ft. 10 ins., and beyond this are the following: Smoking room, 15 ft. 10⅜ ins. × 10 ft. 2¼ ins.; men's toilet room, 10 ft. 5⅝ ins. × 10 ft. 2¼ ins.; news stand, 5 ft. × 8 ft. 9½ ins.; parcel room, 7 ft. 8 ins. × 8 ft. 9½ ins.; pantry, 7 ft. 8 ins. × 8 ft. 9½ ins.; and lunch room, 26 ft. 10 ins. × 10 ft. 4¼ ins. There is also a trainmen's room, 8 ft. 7 ins. × 8 ft. 8½ ins., fitted with lockers and shelves. On the second floor are several rooms which are utilized for office purposes. The waiting rooms are 21 ft. high and the offices in the second story are 10 ft. high. The flooring is of hard maple in the waiting rooms, pine in the baggage room, mosaic in the vestibule entrances, and tile and marble in the toilet rooms. The basement has a concrete floor. A concrete platform extends all round the building, and down to the two side streets, these extensions being covered by roofs.

The following information is extracted from the specifications: The foundations are of concrete, and the bottom of every trench for walls, piers, etc., was wetted and then thoroughly tamped before the concrete was put in.

Mortar and Concrete.—Both Louisville and imported Portland cement were used. The stone for concrete was limestone, broken to a 2-in. size. All cement mortar and concrete was accurately measured and thoroughly mixed dry, with only enough water added to render it of good working consistency. Mortar (except for house plastering) and concrete were made as follows:

Lime mortar: 1 part lime to 3 parts sand.

Lime cement mortar: 1 part Louisville cement to 1 part lime and 5 parts sand; or 1 part imported Portland cement to 1 part lime and 6 parts sand.

Cement mortar: 1 part Louisville cement to 2 parts sand, or 1 part imported Portland cement to 3 parts sand.

Concrete: 1 part Louisville cement to 2 parts clean, sharp sand, and 4 parts clean broken stone; or 1 part imported Portland cement to 3 parts sand and 6 parts stone.

Concrete and Granolithic Work.—Concrete platforms were required to rest on a layer of 8 ins. of clean cinders, and concrete floors on a layer 12 ins. thick. For bottom part of such platforms and floors the specifications required 5 ins. of a mixture of 1 part Portland cement, 2 parts clean sharp "torpedo" sand, and 4 parts crushed stone known as "Dolese & Sheppard's second limestone, fine medium." For the finished surface a 1-in. layer of a mixture of 1 part Portland cement to 1 part screened torpedo sand was called for, the mixture being well worked with a trowel to give a smooth and even surface. Granolithic concrete was specified as 1 part Portland cement, 4 parts 1-in. crushed granite and 2 parts granite screenings. The cement and screenings were mixed dry and wetted to form a stiff mortar, the crushed stone (previously wetted) was then added and mixed. The wearing and face surfaces were finished with a stiff mortar mixture of 2 parts cement to 3 parts screenings. A 6-in. layer of concrete of 1 part Louisville cement, 2 parts clean sharp sand and 4 parts 2-in. broken limestone was laid as a foundation for asphalt-paving blocks on the driveway, etc., these blocks being grouted with a mortar of 1 part Portland cement to 1 part clean sand, mixed dry, and with enough water added to enable it to be poured from a spout. On the concrete were 2 ins. of coarse sand and gravel. All Portland cement was of imported brands.

Brick and Terra Cotta.—The walls, shafts, arches, etc., are of hard burned brick laid in lime mortar (except where cement mortar is specified); the work being what is known as shoved work, well-bedded, tied in every sixth course and worked in regular bond, with full-flushed joints. The bricks were laid wet in warm, dry weather and dry in damp and freezing weather. Hollow walls have a 2-in. air space, the sides being tied across by double hook or channel shaped clamps of galvanized iron set 2 ft. apart in every sixth course. For the face brickwork, brown, red and buff pressed brick with ⅛-in. putty-buttered joints, were called for, the putty being colored with brown Pecora mortar stain. Pressed brick and terra cotta facework was cleaned with a weak solution of acid, and when perfectly dry was given one good coat of raw linseed oil.

Stone.—All cut stone was buff Bedford stone, with rubbed face. Every stone was anchored to the backing with two galvanized wrought-iron anchors, and clamps of the same kind were used to clamp horizontal courses together where necessary. The stones were laid with 3-16-in. joints, raked out ½-in. deep and pointed with brown stained mortar.

The building is heated by a high-pressure steam heating apparatus, with direct radiation. Steam is supplied by two horizontal firebox boilers; with shells of ¼-in. steel; 42 ins. diameter and 10 ft. 6 ins. long, with fireboxes 36 ins. wide, 44 ins. long and 45 ins. high. Shaking and dumping grates will be used. The total amount of net radiation on the radiators is 3,035 sq. ft. The single pipe system is used, so arranged that there will be a complete and noiseless circulation with 1-lb. pressure in the pipes. Both gas and electric light fittings are installed, but electric light is now used. The supply conductors are carried to a pole near the station and then led down the pole into a 2-in. galvanized wrought-iron conduit. They enter the building through a conduit of 3-in. vitrified socket-joint

tiling in 24-ft. lengths, all joints being wrapped and treated with a non-absorbent insulating material. A complete system of metal conduits was provided for the interior conductors.

The station was designed by Mr. Francis T. Bacon, Architect of the Illinois Central R. R., erected under the supervision of Mr. H. W. Parkhurst, Engineer of Bridges and Buildings, and all subject to the approval of Mr. David Sloan, Chief Engineer. The contract for construction was let to Scoullar & Bierwirth, of Chicago. The total cost of the work was $75,000, of which $60,000 was for contract work, and the balance for work done by the railway company.

For the benefit of those of our readers who are interested in color schemes for the representation of materials by colors on drawings and tracings, we give the following list taken from the specifications of the Springfield station:

Old work, in section	Black.
Earth "	Brown.
Cinders "	Black dots.
Slag "	Leopard marking.
Concrete and granolithic work, in section	Neutral tint.
Brick work of building, "	Vermilion.
Stone and marble, in section	Dark blue.
Stone and marble, in elevation	Light blue.
Wood, in section	Yellow.
Metal, "	Indigo blue.
Metal, in elevation	Green.
Terra cotta, in section	Dark brick red.
Terra cotta, in elevation	Light brick red.
Roof tile, in section	Carmine.
Sand, "	Orange.
Paving brick and asphalt blocks in section	Scarlet.
Firebrick, in section	Orange dotted.
Plaster, "	Purple.

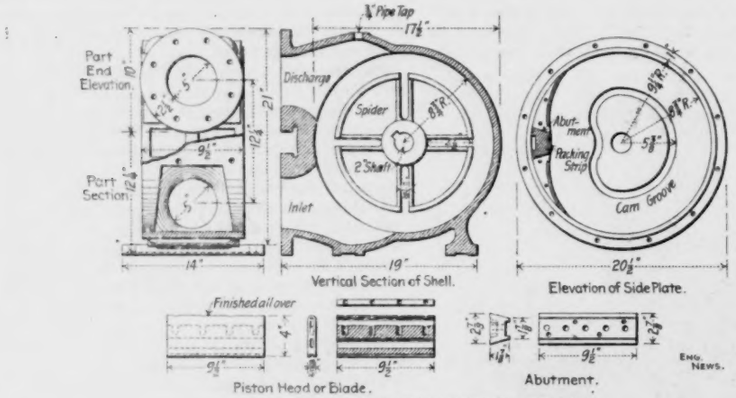
ROTARY PUMP WITH SLIDING BLADES.

The Johnson rotary pump is a valveless pump intended for pumping thin or thick liquids, and is peculiar in that the runner or spider is fitted with sliding blades. The machine is a short cylinder with a horizontal axis, having the inlet and discharge opening on the same side of the circumference, and directly above one another. These openings are separated by an iron cross bar or "abutment" fitted into dovetailed sockets, and projecting within the pump chamber. This is set up by a spring, and has a packing strip on the face. The runner or spider, which is keyed to the shaft, has four radial slots in which are fitted blades or piston heads the full width of the chamber, and having studs projecting at each end. The side plates or cylinder heads are attached to the cylinder by bolts passing through their flanges, outside the cylinder, and on the inner face of each plate are formed the sockets for the abutment and a cam-shaped groove which receives the studs and rollers on the ends of the blades. The sockets also form guides for the faces of the blades. As the spider revolves, the rollers running in the cam grooves draw each blade in as it approaches the abutment, thus allowing it to pass that obstruction, after which it is forced out against the wall of the pump chamber.

The machines are made in various sizes. The one illustrated has an inside diameter of 17½ ins., and a width of 9½ ins. between the cylinder heads. The spider or runner has slots 4½ ins. deep, in which slide the piston heads, which are 4 ins. long and 9½ ins. wide. The inlet and discharge openings are 5 ins. diameter.

The pump is reversible, and may be operated at low speed. For the smaller sizes, with 1½ and 2-in. suction and discharge, the pump is run at 225 revolutions per minute (40 to 70 gallons capacity), while the 4-in., 5-in. and 6-in. pumps are run at 125 revolutions, giving a capacity of 500 and 750 gallons per minute respectively. The blades are of steel or bronze, as required for the work to be performed. The reciprocating movement of these blades allows for the passage of chips, tanbark, gravel and other solid matter. The pump is adapted for handling water, grain and water, soap and glue stock, molasses, malt,, starch, etc., and is made of iron, bronze or an acid proof alloy for pumping acids, tanning liquid and chemicals, for all of which purpose it has been employed. It may be driven by belting, or may be coupled direct to a steam or gas engine, or an electric motor.

This pump is manufactured by the Davis Johnson Co., 41 W. Randolph St., Chicago, and we are indebted to that firm for blue prints from which our illustrations are made.



ROTARY PUMP WITH SLIDING BLADES.
The Davis Johnson Co., Makers.

BOOK REVIEWS.

METRICAL TABLES.—By Sir Guilford L. Molesworth. Third edition, revised and enlarged. New York: Spon & Chamberlain. Leather; 4½ × 3 ins.; pp. 86. 80 cts.

In this edition several new tables have been added which have been found useful in commercial electrical transactions between England and Continental nations. The converting tables cover almost every desired comparison of linear, square and cubic measurements; measures of capacity and weight; combinations; prices; electrical and heat computations. It gives the complete list of metric contractions adopted by the Paris Conference of 1881 and still in force.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.—Proceedings of 48th Meeting, Columbus, O., August, 1899. Address Assistant Secretary, C. A. Watson, North Andover, Mass. Paper; 9¾ × 6 ins.; pp. 527; illustrated. $1.50.

Contents: A Problem in American Anthropology, F. W. Putnam; The Fundamental Principles of Algebra, Alex. Macfarlane; The Field of Experimental Research, Elihu Thomson; The Definition of the Element, F. P. Venable; Engineering Education as a Preliminary Training for Scientific Research Work, Storm Bull; The Devonian System in Canada, J. F. Whiteaves; The Importance and the Promise in the Study of the Domestic Animals, Simon Henry Gage; The Progress and Problems of Plant Physiology, Chas. R. Barnes; The Beginnings of the Science of Prehistoric Anthropology, Thomas Wilson; The Early Presidents of the American Association, Marcus Benjamin. The above include the full papers by vice-presidents or chairmen of sections. It does not include the large number of papers by members, given in abstract or read by title only.

NOTES ON WATER SUPPLY.—Containing References, Tables, Notes, Memoranda and Detailed Advertisements in Relation to Water-Works Engineering; also Illustrated Description and Prices of Apparatus, Appliances, Tools and Material Required on a Water-Works. By J. T. Rodda, Assoc. M. Inst. C. E. Eastbourne, Eng.: The Author. Cloth; 9 × 11 ins.; pp. 140; illustrated. 5 shillings in England; $2 in America.

This appears to be primarily a collection of advertisements of water-works supplies, supplemented by "notes and references," as the author terms them. Most of the latter sound like "reading notices," but nevertheless they convey some valuable information. Besides the text of the character just mentioned, the book contains other matter of a general character, including some useful tables. The index is printed on ruled writing paper, with ample room for notes. Of course such a volume is chiefly useful in England, but it contains a few American advertisements and descriptions of some devices not in use or not readily obtainable in this country which might possibly be of service to managers of American waterworks plants.

ATLAS OF THE STATE OF PENNSYLVANIA.—Prepared Under the Direction of Joseph R. Bien, E. M., from Original Surveys and Various Local Surveys Revised and Corrected; Based on the Triangulations and Surveys of the U. S. Geological Survey, U. S. Coast and Geodetic Survey, U. S. Lake Survey and Second Geological Survey of Pennsylvania. New York: 1900: Julius Bien & Co. Cloth; 20 × 15 ins.; 47 maps; $20.

This very handsome atlas of the State of Pennsylvania commences with a general index containing over 8,000 names and giving full information as to counties and county seats, post offices, railway stations, telegraph and express offices,etc. The area in square miles of the various counties are newly computed, and the claim is made that it is the first time the correct areas have been published. Aside from the separate maps of counties and large maps of cities, we have a folding map of the whole United States, reduced from the 9-sheet map of the U. S. Geological Survey, a railway and post-office map, an economic and geological map, rainfall and temperature map, a relief map, and a plate of statistical diagrams showing the volume of manufactures and the agricultural and mineral products of the state for 1890. The county maps are on a uniform scale of 3 ins. to one mile; and the city maps have all either been prepared by the City Engineers, or are certified as correct by these officials.

FOREIGN PATENT AND TRADE-MARK LAWS.—A Comparative Study with Tabular Statements of Essential Features of Such Laws, Together with the Text of the International Convention for the Protection of Industrial Property Concluded at Paris, March 20, 1883, as Amended, with Notes Thereon, and Other Conventions and Treaties of the United States Relating to Patents and Trade-Marks. By Arthur P. Greeley, Assistant Commissioner of Patents, Member of Commission to Revise Patent and Trade-Mark Laws of the United States, Appointed under Act of Congress, Approved June 4, 1898; Member of American Bar Association. Washington, D. C.: John Byrne & Co. Sheep; 7 × 10 ins.; pp. 319. $5.

This is an exceedingly well prepared and useful work, and one calculated to be of great service to inventors and manufacturers. While attorneys making a specialty of patent and trade-mark litigation will naturally be its chief purchasers, the matter is so clearly and plainly presented that the layman can make use of it; and will find it a valuable guide in considering all matters pertaining to the obtaining, purchase or sale of foreign patents.

The portion of the book relating to trade-marks is of especial interest at this time, when increasing attention is being paid to export trade by American manufacturers. It is a fact not generally known that unless American manufacturers secure protection for their trade-marks in the countries to which they send their goods by registering them as provided for in the laws of such countries, they will be helpless so far as infringement is concerned. For this reason the book should find a place in the office of many American manufacturers engaged in the foreign trade, and its hints may save them many times its cost annually.

ELECTRICITY AND WATER POWER.—A Popular Treatise Designed to Help the Business Man, the Mechanic and the Student to Form Reliable Conceptions as to the Fundamental Principles of Electricity and Water Power. By Mark A. Replogle, Engineer. New York: Electrical Review Publishing Co. 4 × 6 ins.; pp. 161; 9 illustrations. $1.

The author of this book states in the preface that it is his wish to put the principles of electrical science into plain language, and in such a light that the busy man, the mechanic and the beginner can form conceptions that will bear them out in reasoning or in making general calculations.

If he succeeds in dispelling the cloud of mystery that prevents many from seeing clearly the causes of electrical phenomena, * * * he will feel that his work has accomplished its purpose.

How near he has approached to success in his attempt to accomplish this laudable purpose may be judged from the following extract.

The material universe contains a never-varying quantity of electricity, and each atom of matter inherits by the laws of nature its share, depending somewhat on the nature of the matter itself. If every atom of matter contained its portion at any one time, no electrical phenomena could be seen or discerned at such time.

All motion of electrical force is regulated by the law of supply and demand.

* * * * * * * * * *

Lines of magnetic force are nothing more than rows of atoms polarized; that is, arranged in regular order. It will be remembered that each atom of matter is supposed to have a positive and a negative pole, and when the atoms of any portion of material are polarized it becomes a magnet. So magnetism is nothing more than a condition of the material surrounding an electric current, and it is not electricity. We only know that this is a fact; but none can tell whether it is out of respect to the passing current or whether some unknown law compels lines of magnetism to run around the passing current.

In teleological matters our author would evidently be denominated a qualified determinist, but in the domain of science he might be disposed of with a less dignified title.